AN ANALYSIS OF UNPLANNED REQUIREMENTS AND THEIR IMPACT ON THE NAVAL ELECTRONIC SYSTEMS COMMAND

Justin Daniel McCarthy

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

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AND THEIR IMPACT ON THE
NAVAL ELECTRONIC SYSTEMS COMMAND

by

Justin Daniel McCarthy
John Thomas Quinn
June 1976

and

William Byrd James
March 1976

Thesis Advisor F.R. Richards

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The Naval Electronics Systems Command (NAVELEX), as one of the Navy's Hardware Systems Commands, is vitally concerned with its ability to supply the fleet needed equipments when failures occur. Their ability to accomplish this goal is currently restricted by Naval policy which prohibits the funding of unplanned requirements for principal end items. As a partial solution to this problem, NAVELEX has developed alternate sources

20. Abstract (Continuation)

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by

Justin Daniel McCarthy
Lieutenant, Supply Corps, United States Navy
B.S., Oakland University, 1969

and

John Thomas Quinn
Lieutenant Commander, Supply Corps, United States Navy
B.S., U.S. Naval Academy, 1962

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

June 1976

and

William Byrd James
Lieutenant Commander, Supply Corps, United States Navy
B.A., University of Mississippi, 1965

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

March 1976

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TABLE OF ABBREVIATIONS

ACN	Activity Control Number
APA	Appropriations Purchase Account
BESEP	Basic Electronics Shore Equipment Plan
CASREPT	Casualty Report
CENILE	Cumulative End Item Ledger
CNM	Chief of Naval Material
CNO	Chief of Naval Operations
COMNAVSECGRU	Commander, Naval Security Group
COMNAVTELECOM	Commander, Naval Telecommunications Command
COMSEC	Communications Security
CRAB	Centralized Requisitioning Accounting and Billing
CSSR	Consolidated Stock Status Report
DCA	Defense Communications Agency
DEEP	Direct Equipment Exchange Program
DOD	Department of Defense
EDICT	Equipment Dictionary
ELEX	Naval Electronics System Command
EW	Early Warning
FAA	Federal Aviation Agency
FMP	Fleet Modernization Program
FMS	Foreign Military Sales
FYDP	Five Year Defense Plan
GPETE	General Purpose Electronic Test Equipment
HSC	Hardware Systems Command
ICP	Inventory Control Point
ILS	Integrated Logistics Support
IM	Inventory Manager
MDF	Master Data File
MILSTRIP	Military Standard Requisition and Issue Procedure
MIPR	Military Interdepartmental Purchase Request
MTIS	Material Turned in to Store
NAVAIR	Naval Air Systems Command

TABLE OF ABBREVIATIONS (continued)

NAVELEX	Naval Electronics System Command
NAVILCO	Navy International Logistics Control Office
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NMC	Naval Material Command
NSA	National Security Agency
NSN	National Stock Number
O&MN	Operations and Maintenance, Navy
OPN	Other Procurement, Navy
PLT	Procurement Lead Time
POM	Program Objective Memorandum
PPR	Planned Program Requirement
RACC/ATS	Requirements Accumulator/Acquisition Tracking System
RADIAC	Radio Active Test Equipment
RAV	Restricted Availability
RDD	Required Delivery Date
RDT&E	Research, Development, Test and Evaluation
RTAT	Repair Turnaround Time
SAMIS	Ship Alteration Management Information System
SCN	Shipbuilding and Conversion, Navy
SHP	Standard Hardware Program
SPCC	Ships Parts Control Center
SPD	Ships Project Directive
SUPAD	Supplementary Address
TIR	Transaction Item Reporting
TYCOM	Type Commander
UIC	Unit Identification Code
UICP	Uniform Inventory Control Point
UMMIPS	Uniform Material Movement and Issue Priority System
WISSA	Wholesale Interservice Supply Support Agreement
WSF	Weapons System File

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I. PROBLEM STATEMENT

The ability to manage inventories effectively (i.e. ensure that required supplies are where they are needed, when they are needed) has been the topic of heated debates since the concept of inventory control originated. Among the largest and most audible arenas for such debate is the military community, where the country's defense often rests on the ability to provide needed supplies in a timely manner.

Inventory control, for purposes of this discussion, is exercised over two major categories of material: secondary and principal end items. A principal end item is a major equipment which is an entity in itself while a secondary end item is normally considered to be a portion of a principal end item, specifically a piece part or module (see Appendix A for a more thorough discussion of these terms). Obviously therefore, a key element in the maintenance of responsive military forces is the reliability of principal end items and the availability of secondary end items to support them.

One of the common fallacies in considering the characteristics of principal end items is the belief that once installed, they never require replacement, only repair through the use of secondary end items. Although in the majority of cases this assumption may be appropriate, in a significant number of cases this does not hold true. Unfortunately, it is just this type of philosophy upon which many of the Navy's inventory control policies are based. One such policy pertains to the funding of principal end item inventories.

The financing of Navy principal end item inventories revolves around the concept of planned requirements. Since,

it is believed, principal end items never fail in total, a planned program of installation and modernization should provide the only source of Navy requirements. Given that these planned requirements are, in turn, identified sufficiently in advance of installation, funding support can be provided and acquisition action taken to ensure material is available when required. Notice that, under such a system, no inventories need be accumulated since all requirements are known in advance and can be supplied directly to the customer concerned. If this were the case, inventory management of principal end items from a demand viewpoint would consist of a relatively trivial management exercise. Unfortunately, this is not the case.

The major factor which disturbs this utopian system is unplanned requirements, those requirements which arrive at Hardware Systems Commands (HSC) with no prior planning documentation. The receipt of such requirements from Navy customers normally represents failure of a principal end item which is beyond the capability of the user to repair, even with the use of secondary end item support. This creates a problem to the HSCs, since non-correctable principal end item failures are not provided for in Navy funding policies and no inventories exist to support these requirements. Furthermore, since funds are not allocated to the custcmer activity, the HSCs are theoretically unable to satisfy these demands. As a result of this situation, HSCs have been forced to seek alternative sources of supply in an attempt to satisfy these demands. In fact, such action has, in some cases, forced more efficient use of Navy assets such as the recycling of stricken ship and base closure assets. However, in other cases it has seriously jeopordized the timely completion of future planned programs when assets were borrowed to satisfy the more immediate unplanned requirement and replacement material did not arrive in sufficient time to meet the program's required delivery date

(RDD).

Currently, it is NAVELEX's opinion there is danger that the alternate sources, previously relied upon to satisfy these unfunded unplanned requirements, will not be available to the extent they have been in the past. Therefore, a concerted effort is beginning to emerge on the part of the various HSCs to attempt to remedy this situation. It was for this reason that the Naval Electronics Systems Command (NAVELEX) requested the assistance of the Naval Postgraduate School in analyzing this problem. Specifically, it was requested that an analysis be conducted into the feasibility of submitting a substantiated budget request in support of unplanned requirements.

II. PLAN OF ANALYSIS

To satisfy NAVELEX's desires most effectively it was originally felt a mathematical model would be developed which would enable projections of demand and asset positions, by category, into the near future. Such a model would allow evaluation of the anticipated magnitude of unplanned requirements and the availability of the various sources of assets commonly utilized to support these requirements.

In creating such a model, it was essential that reliable data exist in order to develop historical trends. These trends, in turn, could be analyzed to determine the variable relationships which would form the foundation of the model. For example, each category of demand was to be plotted over time from data extracted from the Cumulative End Item Ledger (CENILE) tape, a tape purported to contain a historical record of all transactions received by NAVELEX since approximately 1965. Given this data, an analysis was to have been conducted to determine those variables which best predicted the demand pattern in each category.

Similarly, historical asset records were to be examined with the intention of plotting the degree of NAVELEX's reliance on each asset category. Once again, a variable analysis was to have been conducted to enable asset usage projections to be made. Given both this data and the results of the demand analysis, a plot was to have been constructed showing both the level of unplanned requirements anticipated in the near future, and the level of assets anticipated to support these requirements. Such data, would either substantiate or refute the contention that a serious

shortage of the assets commonly used to satisfy unplanned requirements was inevitable.

Finally, given that the initial analysis confirmed NAVELEX's contention that a shortage of assets was imminent, one further analysis was intended. Since the only system currently in use in the Navy for demand forecasting is designed to accomodate relatively consistent and stable demand distributions, it was doubtful this system could be applied to principal end item demand. Therefore, it was anticipated alternative inventory models would be compared to determine if a more reliable model existed which could be used to forecast principal end item demand and to manage inventories of spare principal end items. Once again, the successful completion of this portion of the analysis centered on the inventory data from which to evaluate each model.

The availability of reliable data sources in evaluating such models is critical. First, an inventory system is dependent upon the ability to forecast demands. Such capability provides the requirement base from which inventory requirements are computed. Given these demands, inventory characteristics provide the basis for determining the source of assets and the timing necessary to ensure material is available in advance of the requirement. For example, items for which a forecast exists are often provided for through repair. In such a case, the inventory manager must first have unserviceable carasses available for repair and secondly must know the survivability of those carcasses (i.e. it may take five carcasses to obtain four serviceable assets). Furthermore, from a funding standpoint, the cost to repair must be known to determine the amount of funds to be committed to this repair. Thus, not only must the demand be accurately forecasted, but the inventory

characteristics such as repair cost, survival rate, and time to repair must be known.

Therefore, the initial plan was heavily dependent upon the availability of three distinct data bases: historical demand, historical asset usage, and line item characteristics (i.e. the essential elements of each item of inventory such as time to procure, replacement price, cost to repair, time to repair, etc.). Unfortunately, none of the three was available to the extent necessary to conduct the intended analysis. The historical data base provided by the CENILE tape, although closest to that desired, provided reliable data for a period of only four years. Prior to that time the demand reflected on the tape was not representative of NAVELEX's demand experience. Furthermore, no completely reliable method of differentiating the various categories of demands on the tape was available (although a reasonable approach that is discussed later was determined).

In the case of the required asset data base, sufficient records of historical usage did not exist for some of the key sources utilized to satisfy unplanned requirements. Furthermore, those records which did exist could not identify the degree of dependence of NAVELEX on each source. Finally, analysis of the line item characteristics of NAVELEX's inventory revealed a considerable amount of unreliable data, as will be discussed later.

As a result, the initial plan was abandoned and an alternate adopted. Considering the possible consequences of NAVELEX's contention, it was felt any evidence which could support the need for funding of unplanned requirements would be beneficial. At the same time it was recognized that considerable evidence would have to be presented to justify

the funding of unplanned requirements in the eyes of budget analysts. Therefore, the direction of this analysis changed to one of determining if sufficient evidence exists to support the execution of a "clean-up" effort. Given such evidence, NAVELEX could, in turn, justify the expense of undertaking such an effort with the ultimate intent of conducting an analysis of the type originally planned.

Given this change in direction, the analysis now centers on three major functional areas: inventory characteristics, demand analysis and asset analysis. In the case of inventory characteristics the intent is to identify those areas which require attention before available data can be used for demand forecasting. This is to be accomplished through an analysis of the data currently utilized by NAVELEX.

Secondly, a demand analysis is to be conducted to determine the validity of current Uniform Inventory Control Point (UICP) forecasting procedures as they relate to principal end items. This will be accomplished by analyzing the reliability of the sample UICP forecasts and by determining if principal end item demand patterns are compatible with the UICP model's capabilities.

Finally, an analysis of NAVELEX's reliance on each asset source will be conducted within the limits of available supporting data. This together with on hand inventory balances currently available to support unplanned requirements will be analyzed to determine if an asset shortage is anticipated.

III. ANALYTICAL RESULTS

A. Inventory Characteristics

Any attempt to stratify assets over some demand horizon requires the availability of certain essential data elements referred to here as inventory characteristics. Considering the routine sources of assets utilized by NAVELEX and outlined in Appendix B, such characteristics include:

(1) the time required to obtain material through procurement (i.e. procurement lead time or PLT),

(2) the time required to complete repair of an unserviceable asset (i.e. repair turn-around-time or RTAT), and

(3) the probability that an item that is inducted into repair could in fact be returned to a serviceable condition (i.e. survival rate).

Two alternative sources of inventory characteristics such as those mentioned above are maintained by NAVELEX: the Uniform Inventory Control Point (UICP) Master Data File (MDF) and the Equipment Dictionary (EDICT). Since the latter file's primary function is to record technical data and the former's to record inventory control data, and since the two files are purported to be comparable as far as inventory characteristics are concerned, the MDF was selected as the source for the analysis of the inventory characteristics of the assets of NAVELEX.

In an attempt to identify aggregate inventory characteristics as well as provide insight into possible areas of further analysis, key elements of the MDF for all items managed by NAVELEX were extracted through the use of

the Consolidated Stock Status Report (CSSR) outputs. Figure III-1 displays a summary of these characteristics.

Inventory Characteristics Summary

Number of items managed	2038
Percent repairable	90.5%
Percent with zero demand	81.2%
Average item age (years)	4.2
Average quarterly demand (equipments)	11.3
Average quarterly demand (dollars)	$4,897,687
Average quarterly frequency (documents)	2.7
Average PLT (quarters)	3.8
Average RTAT (quarters)	1.6
Average repair cost	$19,945
Average replacement price	$24,109
Average survival rate (percent)	85.0%

Figure III-1

Note that 9.5% of NAVELEX's inventory represents non-repairable (i.e consumable) items, and that 18.8% of the inventory experiences non-zero demand. Both these results contradict the common beliefs that principal end items do not experience unplanned requirements and that they are all repairable. Therefore, three possible inferences could be made:

(1) NAVELEX was managing items which do not fit in the category of principal end items,

(2) the commonly held opinions on principal end

item characteristics were in error, or

(3) the MDF data base did not reflect the true nature of NAVELEX's inventory.

Figure III-2 reflects a more complete stratification of NAVELEX inventory characteristics, including separate displays for non-zero demand equipments, consumable equipments, and equipments with a replacement price of less than $100. Incorporated into this statification were several validity checks which resulted from the discovery of common entries in the data elements of several items. For example, during compilation of the MDF data, several PLT entries of 2.4 and 4.0 were observed. Similarly recurring entries of 85% survival rates as well as 1.6 and 1.7 RTATS were noticed. The existence of such system constants normally arise during the establishment of an item on the MDF. When the file is initially loaded, no data are available since observations have not been taken on some data elements. As a result, a representative constant is utilized on a temporary basis pending future observations. In the case of fast moving secondary end items such a constant is on the file only a short time and is therefore of little significance. But in the case of principal end items, the inventory is generally slow moving and such system constants remain in the file for extended periods. Even when actual data becomes available, the original constants are often not updated. In order to determine the significance of system constants in NAVELEX's inventory data, counts of these suspected quantities were incorporated in the data of figure III-2.

Several of the relationships evident in figure III-2 were anticipated. For example, a disproportionate percentage of non-zero demand equipments are national stock numbered (NSN). This follows from the fact that activity

	TOTAL INVENTORY	CONSUMABLE INVENTORY	NON-ZERO DEMAND INVENTORY	LOW COST INVENTORY
TOTAL INVENTORY RECORDS	2038	194	384	227
NATIONAL STOCK NUMBERS	75.8%	67.5%	98.7%	71.4%
ACTIVITY CONTROL NUMBERS	24.2%	32.5%	1.3%	28.6%
PERCENT REPAIRABLE	90.5%	-0-	91.4%	27.3%
PERCENT WITH ZERO DEMAND	81.5%	83.0%	-0-	80.6%
AVERAGE ITEM AGE (years)	4.2	2.1	6.5	3.5
AVERAGE QUARTERLY DEMAND (equipment)	11.3	2.3	11.3	74.3
AVERAGE QUARTERLY DEMAND (dollars)	$4,898K	$59K	$4,898K	$30K
AVERAGE QUARTERLY FREQUENCY (documents)	2.7	1.7	2.9	4.9
AVERAGE PLT (quarters)	3.8	3.3	3.6	3.3
AVERAGE RTAT (quarters)	1.6	1.7	1.6	1.6
AVERAGE REPAIR COST	$19,950	$1,250	$6,660	$88
AVERAGE REPLACEMENT PRICE	$24,110	$6,840	$10,240	$348
AVERAGE SURVIVAL RATE (percent)	85	85	86	85
PRICE WEIGHTED AVERAGE OF REPAIR COST TO PRICE (percent)	57	50	49	360
PERCENT WITH PLT = 2.4 or 4.0	85.7	97.9	78.6	95.6
PERCENT WITH RTAT = 1.6 or 1.7	81.8	4.1	80.5	68.3
PERCENT WITH S/R = 85%	53.5	3.1	67.2	52.4

FIGURE III-2

control numbers (ACN) are assigned primarily to newly inducted equipments pending assigment of a NSN. Such equipments would have little opportunity to accumulate any demand history. Secondly, the relatively low percentage of low cost repairable items suggests such items are generally more economical to replace than repair, or that repair is not feasible at all as would normally be expected.

In addition to these anticipated results several relationships existed which did not appear to coincide with the type of inventory generally considered to be principal end item oriented. The combination of a low repairable percentage and a high quarterly demand average, such as that found in the low cost inventory, suggests such items are primarily consumable in nature. Furthermore, the relatively low dollar value of demand experienced by both the consumables and low cost inventories appears to confirm this observation. However, the equipment demand in the consumable category is the lowest of the group and the average replacement price is significantly above that of the low cost inventory. This supports the suspicion that, in the aggregate, accurate characteristics of the inventory are not being reflected.

A second area of concern is the stable relationships across the various inventory categories for PLT, RTAT and survival rate. In the case of PLT, for example, consumable items are generally more readily available than the more complex major assemblies of the repairable inventory. Yet the consumable inventory differs from the total inventory base by only 45 days (.5 quarters). Additionally, the mere existence of repair data for consumable items sheds considerable doubt on the validity of the data base. Note that 3.1% of the consumable category have a survival rate entry in the MDF and that 4.1% have RTAT entries.

This suggests a data base problem since consumable items are not repairable. In fact, one of two errors could be occurring, either consumable items are incorrectly reflecting repair data elements or repairables have been incorrectly designated as consumables. With further investigation it was concluded the former is the more likely case. Every consumable item which showed entries in the repair related data fields had an 85% survival rate and a 1.7 quarter RTAT. This supports the contention that the repair entries are in error since both entries represent what are here considered system constants. The fact that such constants exist was supported by the validity checks introduced into the MDF screen. As figure III-2 indicates, 85.7% of the total inventory had PLTs equal to exactly 2.4 or 4.0, while 81.8% of the repairable items had RTATs of 1.6 or 1.7, and 53.5% had survival rates of 85%.

Given the evidence supporting the existence of system constants, it was obvious that any attempt to coordinate future inventory actions with anticipated demand would be futile. In the aggregate any such attempt would be heavily influenced by the system constants incorporated into the file data. Thus, even assuming the demand data were reliable, no accurate funding requirements could be generated in anticipation of this demand since lead time and survival rate data were highly suspect. In fact, in the case of procurement lead time, even the magnitudes of the system constants were suspect since, due to the complexity of NAVELEX equipments, it was doubtful material could be obtained within the time frames implied.

As a result of these findings, further analysis was required to determine if data more representative of

principal end items could be obtained from the data elements which did not contain system constants. In addition, several of the other entries displayed in figure III-2 indicated areas for further analysis. For example, the range in price variations across the various categories suggested additional data in this area was required. Furthermore, the ratio of repair cost to replacement price in the case of the low-cost inventory indicated this too would provide an area for further research. Therefore, histograms were constructed to indicate the distribution of data values in each of the following categories:

(1) survival rate (with and without the system constant of 85%),

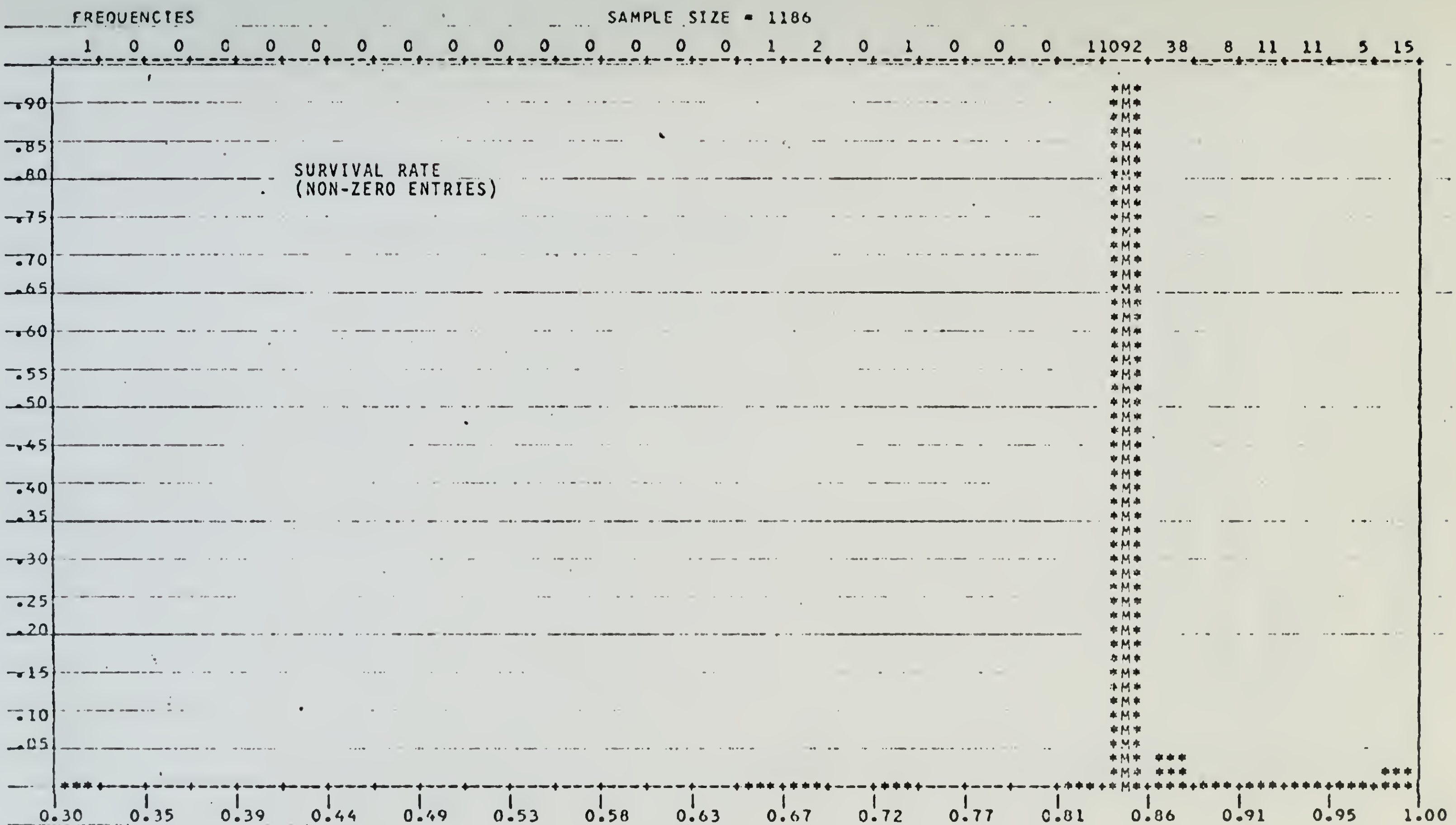
(2) PLT (with and without the system constants of 2.4 and 4.0),

(3) RTAT (with and without the system constants of 1.6 and 1.7),

(4) repair cost to replacement price ratio, and

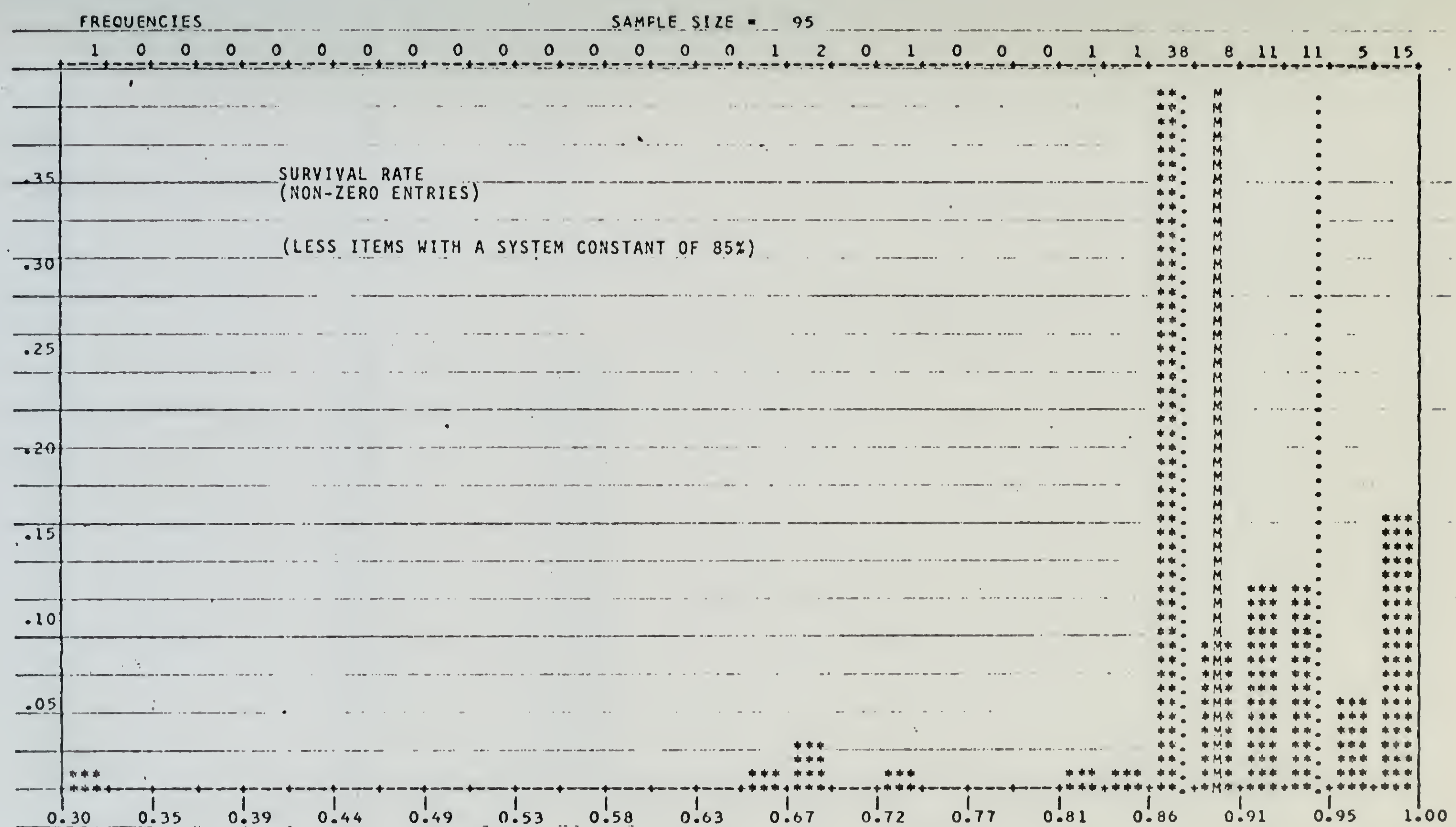
(5) replacement price.

Figures III-3 through III-10 display the results of this analysis. In the case of survival rates, the elimination of 85% system constants had a significant impact. The mean of the distribution shifted from 85% to 90%, a figure more in line with the expected survivability of principal end items. Futhermore, the standard deviation shifted from .03 to .09 as the concentration of values at 85% were eliminated and the distribution was allowed to be more representative of the true data spread. Note, however, that the data are still highly clustered about the range from 88% to 98%. In fact, as can be deduced from the quantile values, 80% of the data falls within this range, indicating a relatively high survivability of electronic



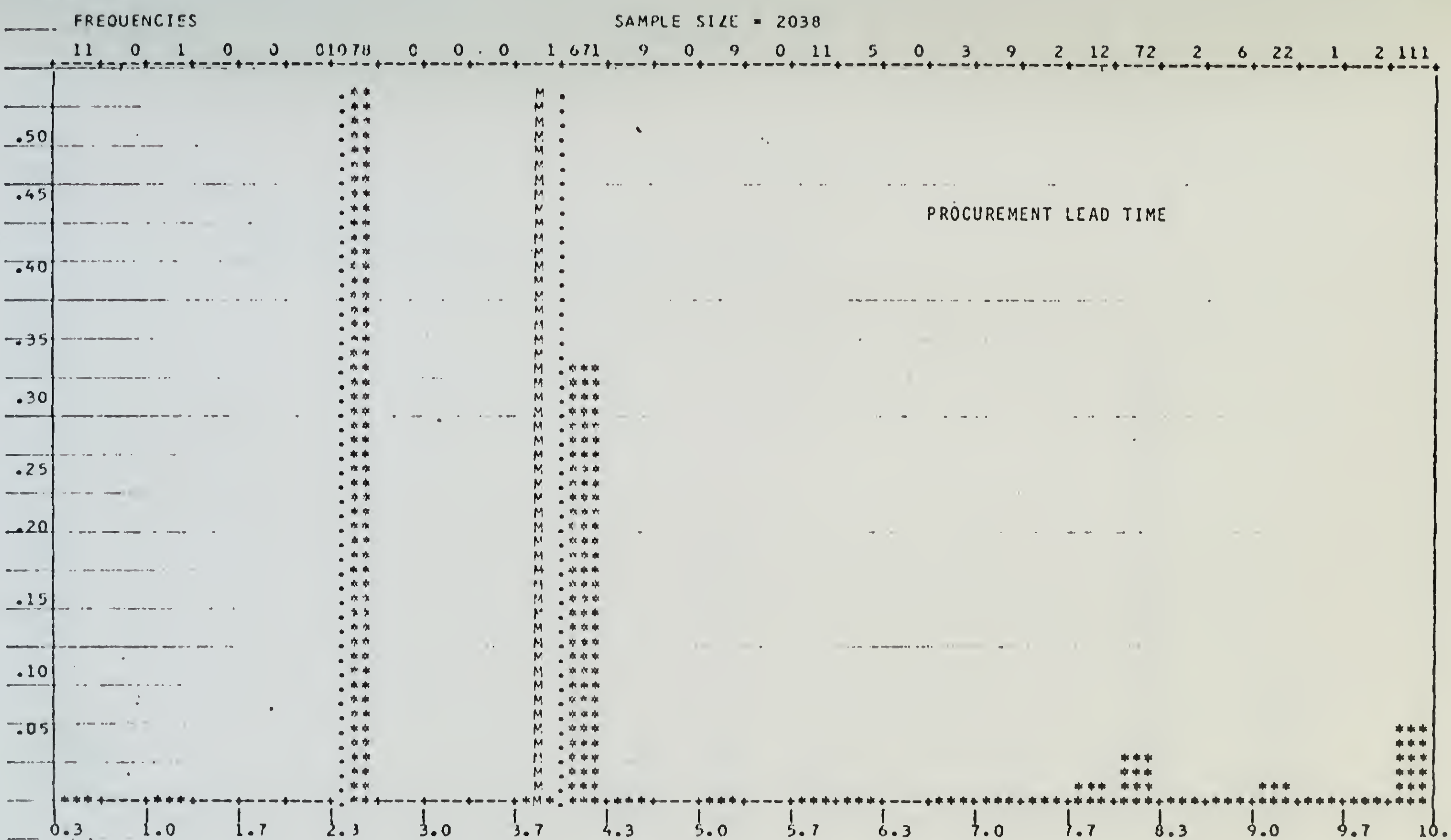
CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	8.540893E-01	VARIANCE	8.147396E-04	M3	-1.102352E-04	MINIMUM	3.000000E-01
MEDIAN	8.499999E-01	STD DEV	2.854364E-02	M4	8.879307E-05	.10 QUANTILE	8.500000E-01
TRIMEAN	8.499997E-01	COEF VAR	3.341997E-02	SKEWNESS	-4.740153E 00	.25 QUANTILE (HINGE)	8.500000E-01
MIDMEAN	8.499999E-01	MEAN DEV	6.146770E-03	KURTOSIS	1.307646E 02	.50 QUANTILE (MEDIAN)	8.499999E-01
MIDRANGE	6.499996E-01	RANGE	7.000000E-01	BETA1	-1.099566E-04	.75 QUANTILE (HINGE)	8.500000E-01
GEOM MEAN	8.534900E-01	MIDSPREAD	0.0	BETA2	8.849696E-05	.90 QUANTILE	8.500000E-01
HARM MEAN	8.526110E-01					MAXIMUM	1.000000E 00

FIGURE III-3



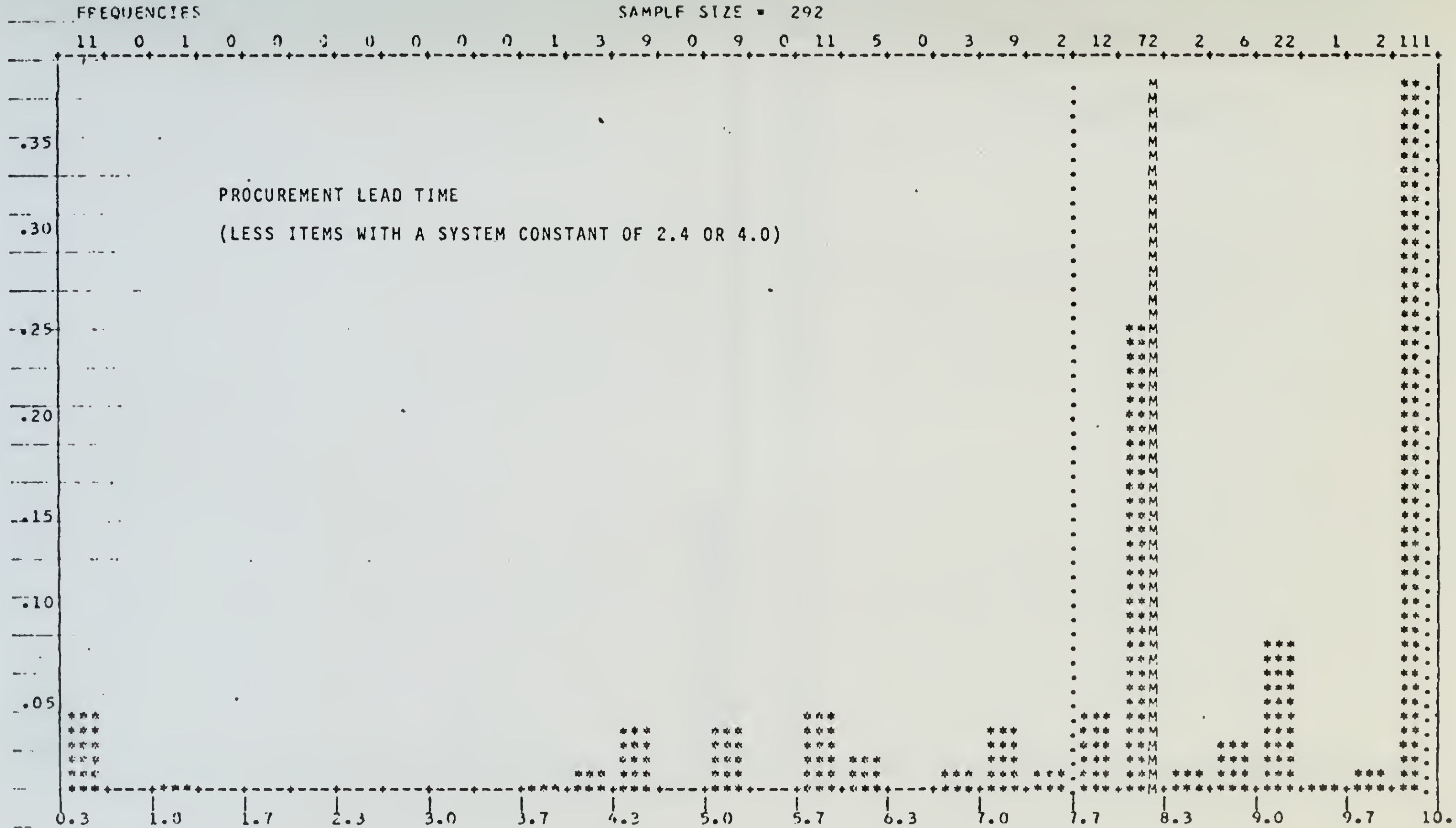
CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	9.010526E-01	VARIANCE	7.847816E-03	M3	-2.652736E-03	MINIMUM	3.000000E-01
MEDIAN	9.000000E-01	STD DEV	8.858788E-02	M4	1.540929E-03	.10 QUANTILE	8.800000E-01
TRIMEAN	9.074958E-01	COEF VAR	9.831595E-02	SKEWNESS	-3.815673E 00	.25 QUANTILE (HINGE)	8.800000E-01
MIDMEAN	9.028571E-01	MEAN DEV	4.989473E-02	KURTOSIS	2.201987E 01	.50 QUANTILE (MEDIAN)	9.000000E-01
MIDRANGE	6.499956E-01	RANGE	7.000000E-01	BETA1	-2.569553E-03	.75 QUANTILE (HINGE)	9.500000E-01
GEOM MEAN	8.946122E-01	MIDSPREAD	6.999999E-02	BETA2	1.479886E-03	.90 QUANTILE	9.800000E-01
HARM MEAN	8.837817E-01					MAXIMUM	1.000000E 00

FIGURE III-4



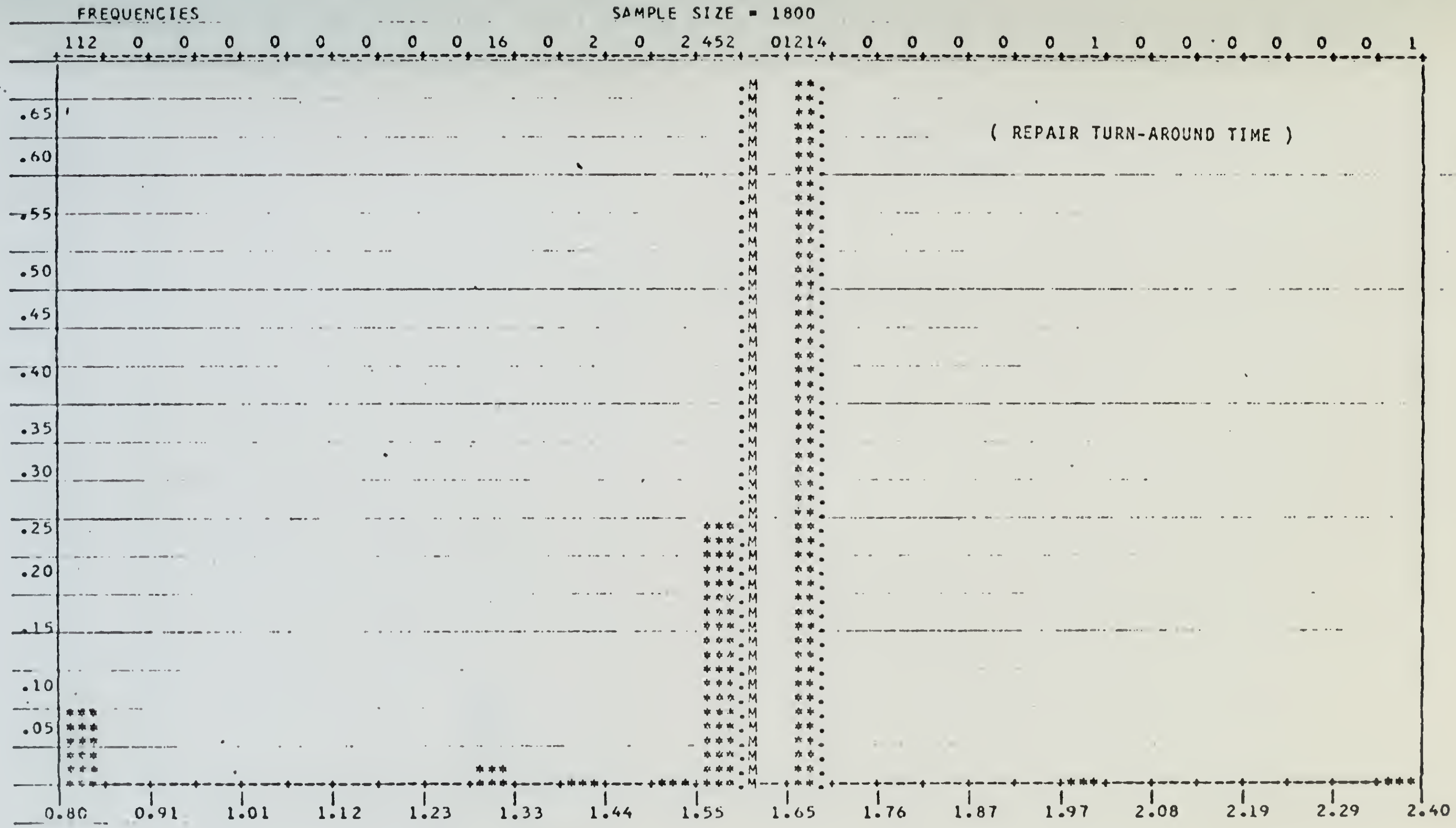
CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	3.766800E 00	VARIANCE	4.738144E 00	M3	1.974562E 01	MINIMUM	3.300000E-01
MEDIAN	2.400000E 00	STD DEV	2.176728E 00	M4	1.310233E 02	.10 QUANTILE	2.400000E 00
TRIMEAN	2.799999E 00	COEF VAR	5.778720E-01	SKEWNESS	1.914512E 00	.25 QUANTILE (HINGE)	2.400000E 00
MIDMEAN	3.088332E 00	MEAN DEV	1.390491E 00	KURTOSIS	2.836227E 00	.50 QUANTILE (MEDIAN)	2.400000E 00
MIDRANGE	5.330000E 00	RANGE	9.999999E 00	BETA1	1.971657E 01	.75 QUANTILE (HINGE)	4.000000E 00
GEOM MEAN	3.333104E 00	MIDSPREAD	1.600000E 00	BETA2	1.308322E 02	.90 QUANTILE	8.000000E 00
HARM MEAN	2.975762E 00					MAXIMUM	1.033000E 01

FIGURE III-5



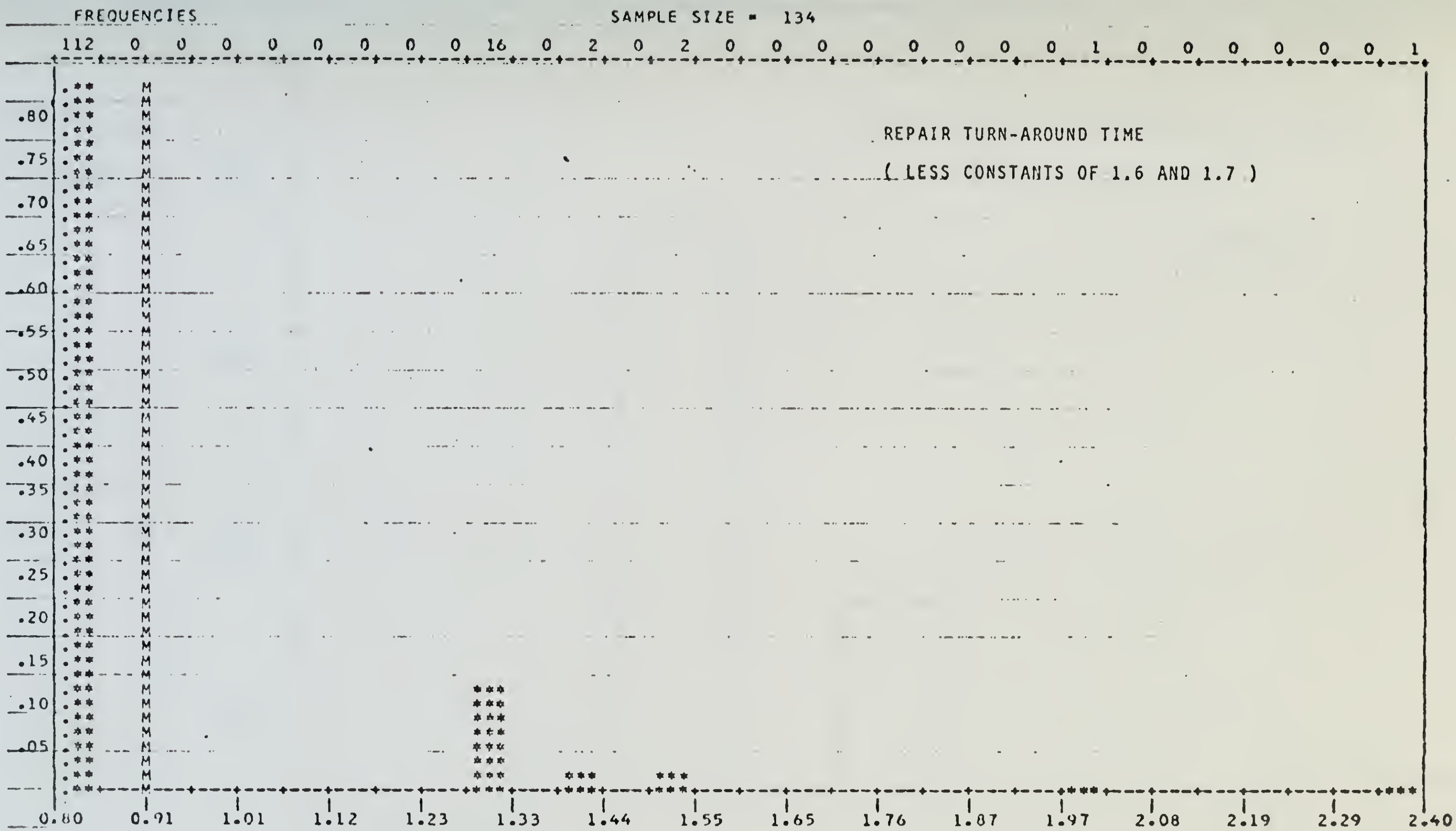
CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	8.279246E 00	VARIANCE	5.689560E 00	M3	-2.185652E 01	MINIMUM	3.300000E-01
MEDIAN	8.299995E 00	STD DEV	2.385280E 00	M4	1.852360E 02	.10 QUANTILE	5.030000E 00
TRIMEAN	8.657494E 00	COEF VAR	2.881035E-01	SKEWNESS	-1.610509E 00	.25 QUANTILE (HINGE)	7.700000E 00
MIDMEAN	8.868013E 00	MEAN DEV	1.724589E 00	KURTOSIS	2.722268E 00	.50 QUANTILE (MEDIAN)	8.299995E 00
MIDRANGE	5.330000E 00	RANGE	9.999999E 00	BETA1	-2.163251E 01	.75 QUANTILE (HINGE)	1.032999E 01
GEOM MEAN	7.382935E 00	MIDSPREAD	2.629994E 00	BETA2	1.833603E 02	.90 QUANTILE	1.033000E 01
HARM MEAN	4.250383E 00					MAXIMUM	1.033000E 01

FIGURE III-6



CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	1.615333E 00	VARIANCE	4.765802E-02	M3	-3.336347E-02	MINIMUM	8.000000E-01
MEDIAN	1.700000E 00	STD DEV	2.183072E-01	M4	2.789933E-02	.10 QUANTILE	1.599999E 00
TRIMEAN	1.674999E 00	COEF VAR	1.351469E-01	SKEWNESS	-3.206765E 00	.25 QUANTILE (HINGE)	1.599999E 00
MIDMEAN	1.685110E 00	MEAN DEV	8.577782E-02	KURTOSIS	9.283489E 00	.50 QUANTILE (MEDIAN)	1.700000E 00
MIDRANGE	1.599999E 00	RANGE	1.599999E 00	BETA1	-3.330790E-02	.75 QUANTILE (HINGE)	1.700000E 00
GEOM MEAN	1.593679E 00	MIDSPREAD	1.000004E-01	BETA2	2.784488E-02	.90 QUANTILE	1.700000E 00
HARM MEAN	1.561681E 00					MAXIMUM	2.400000E 00

FIGURE III-7



CENTRAL TENDENCY		SPREAD		HIGHER CENTRAL MOMENTS		DISTRIBUTION	
MEAN	8.999999E-01	VARIANCE	6.285697E-02	M3	4.808600E-02	MINIMUM	8.000000E-01
MEDIAN	7.999997E-01	STD DEV	2.507129E-01	M4	5.621632E-02	.10 QUANTILE	8.000000E-01
TRIMEAN	7.999995E-01	COEF VAR	2.785699E-01	SKEWNESS	3.051325E 00	.25 QUANTILE (HINGE)	8.000000E-01
MIDMEAN	7.999999E-01	MEAN DEV	1.000001E-01	KURTOSIS	1.122838E 01	.50 QUANTILE (MEDIAN)	7.999997E-01
MIDRANGE	1.599999E 00	RANGE	1.599999E 00	BETA1	4.701481E-02	.75 QUANTILE (HINGE)	8.000000E-01
GEOM MEAN	8.759854E-01	MIDSPREAD	0.0	BETA2	5.471328E-02	.90 QUANTILE	1.299999E 00
HARM MEAN	8.590499E-01					MAXIMUM	2.400000E 00

FIGURE III-8

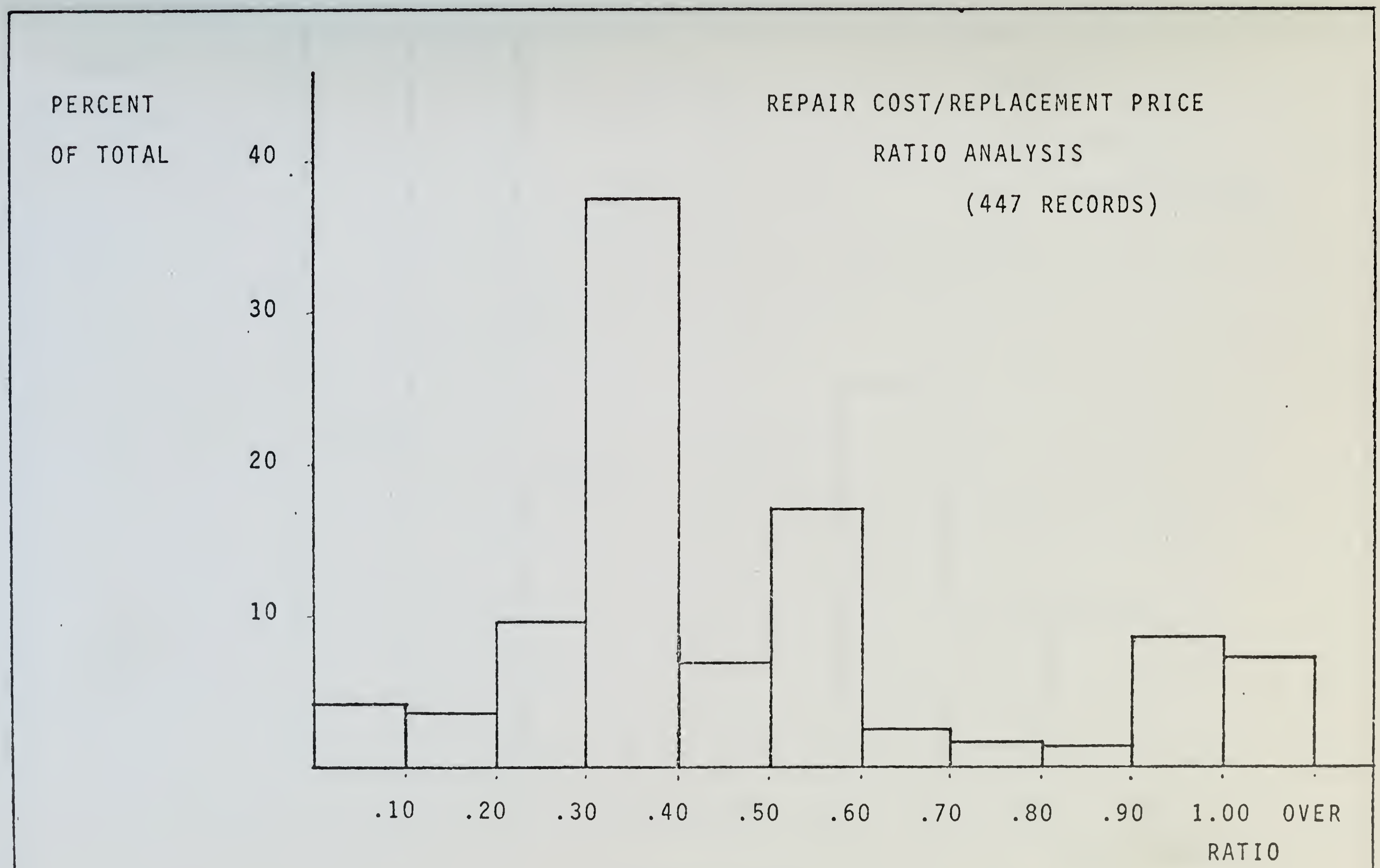

PERCENT
OF TOTAL
REPAIR COST/REPLACEMENT PRICE
RATIO ANALYSIS
(447 RECORDS)
40
30
20
10
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
OVER
RATIO

FIGURE III-9

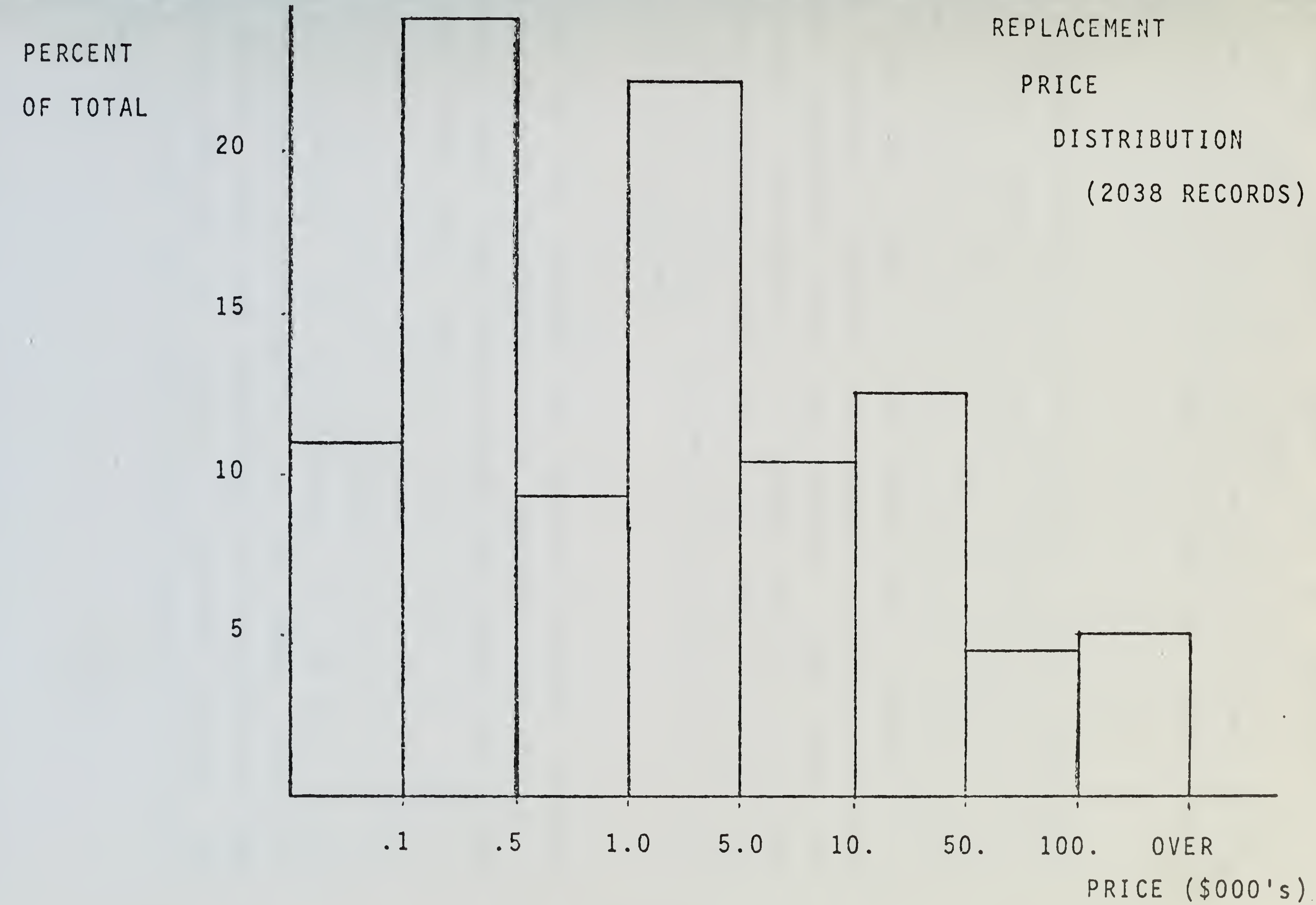


FIGURE III-10

principal end items. This evidence suggests the MDF understates the percentage of the assets available in unserviceable condition which can be returned to a serviceable condition. Such a result, providing repair costs are less than procurement costs, would allow lower funding requirements by greater reliance on repair of unserviceable assets.

A similar analysis of PLT revealed a more significant result after removal of the system constants of 2.4 and 4.0 quarters. Here the mean shifted from 3.8 quarters to 8.3 quarters indicating more than a year's shift toward longer lead times. This result is significant since dependence on these figures to determine the timing of procurements would seriously understate actual requirements. Note also that the overall distribution of values appears to be more reasonably disbursed as the 40% of the values between the 10th and 50th quantile have been distributed over a range from 5.0 to 8.3 quarters.

In the case of RTATs the analysis revealed a shift in the mean from 1.6 quarters to .9 quarters indicating an extremely short repair turn-around-time (RTAT) for NAVELEX principal end items. However, this result is just as questionable as that which included the system constants. Notice the small change in the standard deviation from .22 to .25 indicating the distribution of the data was not heavily affected by the removal of the system constants. Also notice, again from examination of the quantiles, that 75% of the data with the 1.6 and 1.7 constants removed lies at .8 indicating that a third system constant may exist at this point.

Figure III-9 shows that the largest ratio of repair cost to replacement price falls in the commonly accepted range between 30% and 40%, but 15.8% of the items considered have a repair cost which is greater than or equal to 90% of the replacement price. If a policy of repairing items with a repair cost 90% of replacement price is being followed, it would suggest decisions are being made to pay the price of a new item for a repaired asset. The significance of this condition is clarified by the fact that NAVELEX's repair policy is to repair to working condition and not to "good as new". Such a condition suggests a faulty data base although no evidence of system constants could be found in the repair cost data. A second possibility lies in the fact that, for unplanned requirements, the only routine source of material is through repair and, as a result, NAVELEX may be being forced into alternative repair decisions simply because a procurement is not available. Thirdly, equipments currently being supplied through repair tend to be those which have been repaired in the past. Therefore, the repair cost may be up to date while the replacement price may not have been updated since the original procurement, causing the ratio to reflect abnormally high values. Lastly, it is possible that another system constant has crept into the data base and is causing replacement prices to be understated and the ratio to be inflated.

In an attempt to determine the cause of these apparently inflated ratios of repair cost to price, a listing of all items with a ratio in excess of 70% was examined (70% percent was selected as a result of NAVELEX Instruction 4408.2B which requires review of all items with a ratio greater than 75%). Eighty five records, 19% of the records showing a non-zero repair cost, were examined with the following results:

(1) 14% of the records reflected a repair cost and replacement price of $1.00, thereby considered in the analysis as a ratio value of 1.0 (these $1.00 price records will be discussed later).

(2) Replacement prices on the remaining items ranged from $175 to $900,000 with no apparent pattern.

As a result, it appears the most logical conclusion as to the cause of the high ratios is either uneconomical repair/procurement decisions or outdated replacement price data.

Figure III-10 highlights some of the possible problem areas in replacement price data. Although principal end items are commonly thought of as highly complex and expensive, 67% of the equipments have prices of less than $5,000. In an attempt to determine the validity of these prices as well as the possibility of other system constants, all items with a replacement price of $100 or less were reviewed. Of the 11.1% of the total NAVELEX inventory falling into this category, 30.4% had replacement prices of one dollar. These items included a radiacmeter, battery power supply, radar set, air conditioner, radio receiver, antenna, oscilloscope, intermediate amplifier, frequency converter, distribution box, fuse panel and others, none of which appeared to warrant a one dollar replacement price. Additionally, in each case, the item was coded as repairable further indicating the unreasonableness of the one dollar replacement price.

Although no further evidence substantiating the existence of system constants in the replacement price data elements was discovered, the above data, together with that presented earlier led to significant doubts over NAVELEX's ability to stratify assets utilizing the UICP data base.

Considering that, to some extent, all the key stratification elements (replacement price, repair cost, RTAT, PLT, and survival rate) were suspect, it was obvious no accurate forecasts of funding requirements could be made. It was at this point that the decision was made to alter partially the original plan of analysis, since it was obvious that applications of various inventory models would not be possible given the condition of the UICP data base. However, it was still felt that demand and asset projections would be necessary in substantiating the need for the funding of unplanned requirements.

B. Demand Analysis

The prime objective of the demand analysis was to determine the relationships between NAVELEX's various demand categories over time. Although interest centered on the proportion of demand attributable to unplanned requirements, all sources of requirements were to be investigated. The source data for this analysis was extracted from the Cumulative End Item Ledger (CENILE), a magnetic tape file maintained by the Navy Ships Parts Control Center (SPCC). The CENILE tape contains an accumulation of all transactions routed through SPCC involving NAVELEX material. In addition to actual demand documents, such transactions include any inventory management communications between NAVELEX and its various stocking activities which are transmitted through the UICP system. As a result, inventory adjustments, issue directives, revisions to requisitions held, asset balances, and other transaction item reporting (TIR) documentation all appear on the tape. It was essential, therefore, that some reliable system of screening the tape be determined in order to eliminate any transactions which did not represent demand documentation.

Although there was no consistent coding system which would identify all demand documents as well as their respective categories, a system was devised which would reasonably accomplish this goal. Through a combination of various Military Standard Requisition and Issue Procedure (MILSTRIP) data fields (e.g. document identifier, unit identification code, project code, fund code and advice code) a sort was accomplished. However, in the process of developing this sort it was determined that in many cases, numerous records routinely existed on the CENILE tape which could not be handled by a pre-set sort routine without some manual decision being made. These cases centered on quantity variations within the data base for records which had identical requisition numbers. For example, in many cases a single requisition showed five entries on the CENILE tape. These entries would include a planned requirement for a quantity of one, another planned requirement for a quantity of two, a referral order for a quantity of two, a cancellation for a quantity of zero, and an issue directive for a quantity of two. Since, with the exception of the document identifier and the quantity, each document was identical, only one could be utilized as a true demand record. Such a decision had to be made on an exception basis and not as a part of an automated routine.

As a result, the design of the sort routine was intended to maximize the degree of automated processing before relying upon a manual sort. However, it was obvious from the number of records involved (162,101 on the unsorted tape, 135,072 after the first sort) that processing of the complete tape was unreasonable. The decision was made, therefore, to proceed with the sort on a 20% sample basis. This sample, rather than being based upon the number of CENILE records, was extracted from the total NAVELEX inventory (i.e. 20% of the items managed by NAVELEX were selected and a sort performed on the CENILE data applicable

to those equipments). In order to ensure random selection of the sample, all stock numbers ending in the number 8 or 9 were selected and analyzed using the item characteristic routines developed previously. As shown in figure III-11, the sample showed reasonable similarity to the inventory as a whole. Futhermore, the sample while representing 19.4% of the items managed by NAVELEX also represented 20.4% of the CENILE records. Therefore, the sample was considered to be representative of the entire inventory as well as the demand base being analyzed.

Sample Characteristics

	Total Inventory	Sample
Number of records	2038	396(19.4%)
Percent NSN	75.8	75.8
Percent ACN	24.2	24.2
Percent with PLT = 2.4 or 4.0	85.7	84.8
Percent with S/R = 85%	53.5	54.5
Percent with RTAT = 1.6 or 1.7	81.8	83.8
Percent with zero demand	81.2	80.3
Percent repairable	90.5	90.9
Average item age (years)	4.2	4.4

Figure III-11

Appendix C outlines the procedures utilized in conducting the screen of the CENILE data, figures III-12 thru III-17 display the initial results of the screen. In the aggregate, figures III-12 and III-13 suggest the screening

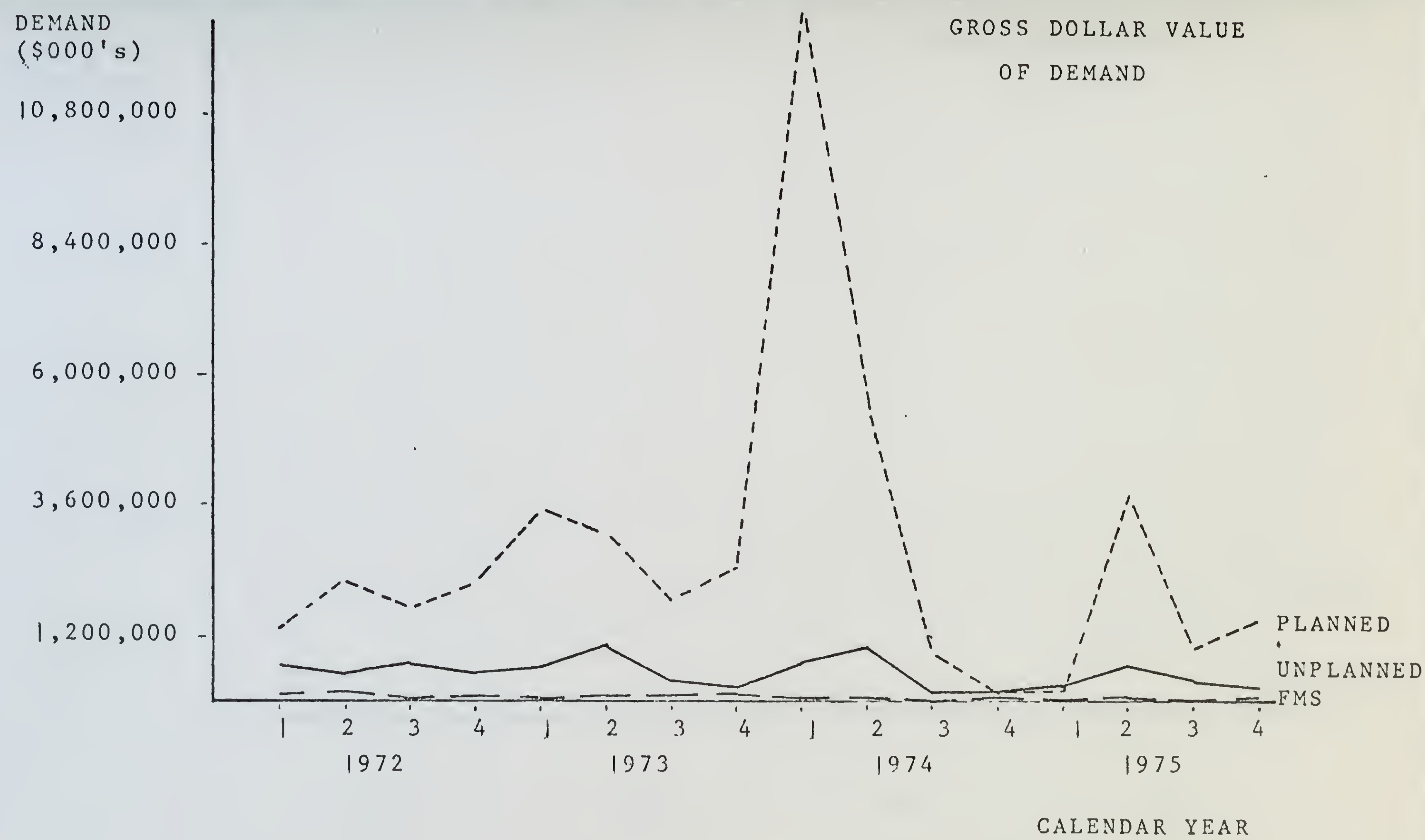


FIGURE III-12

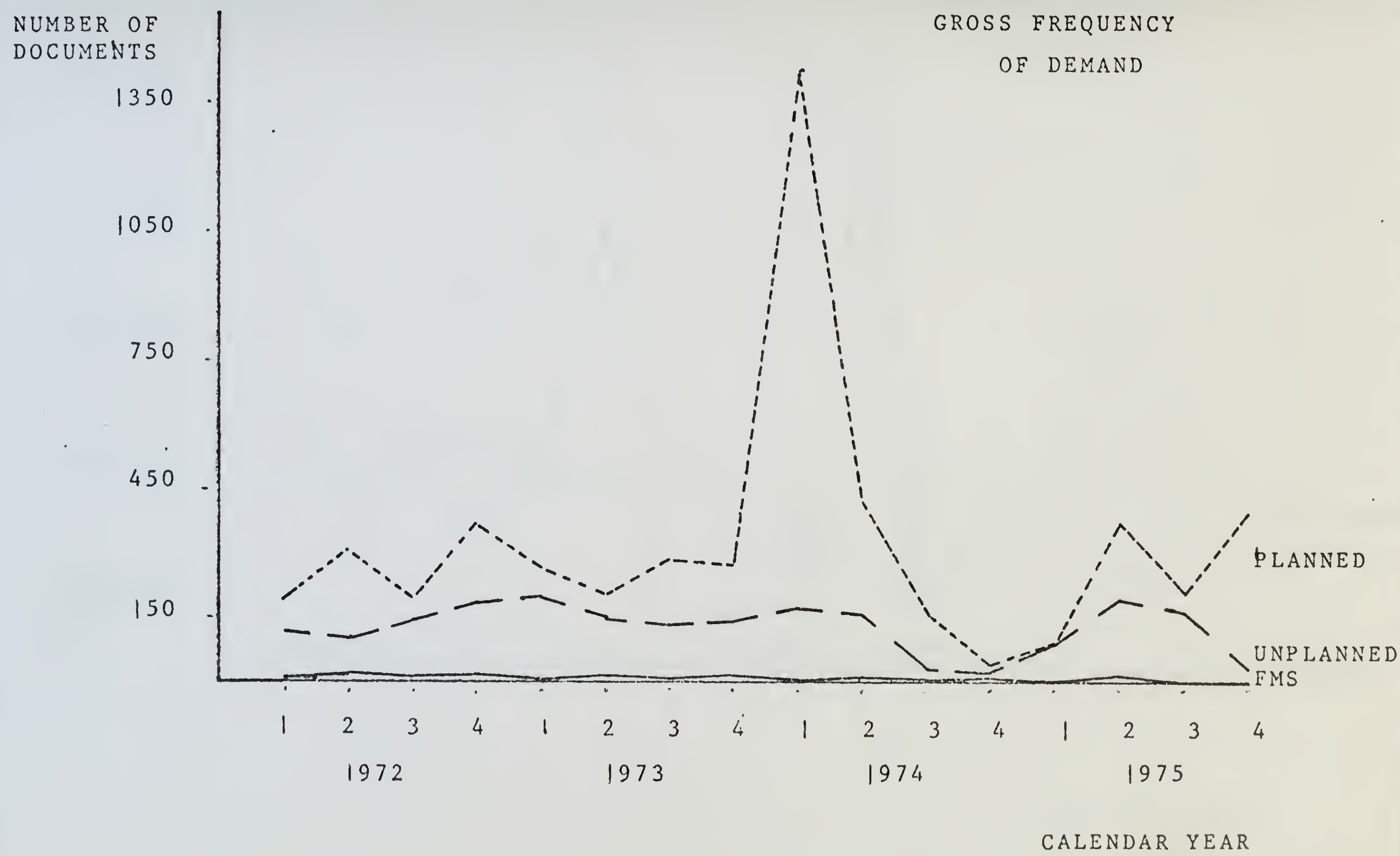


FIGURE III-13

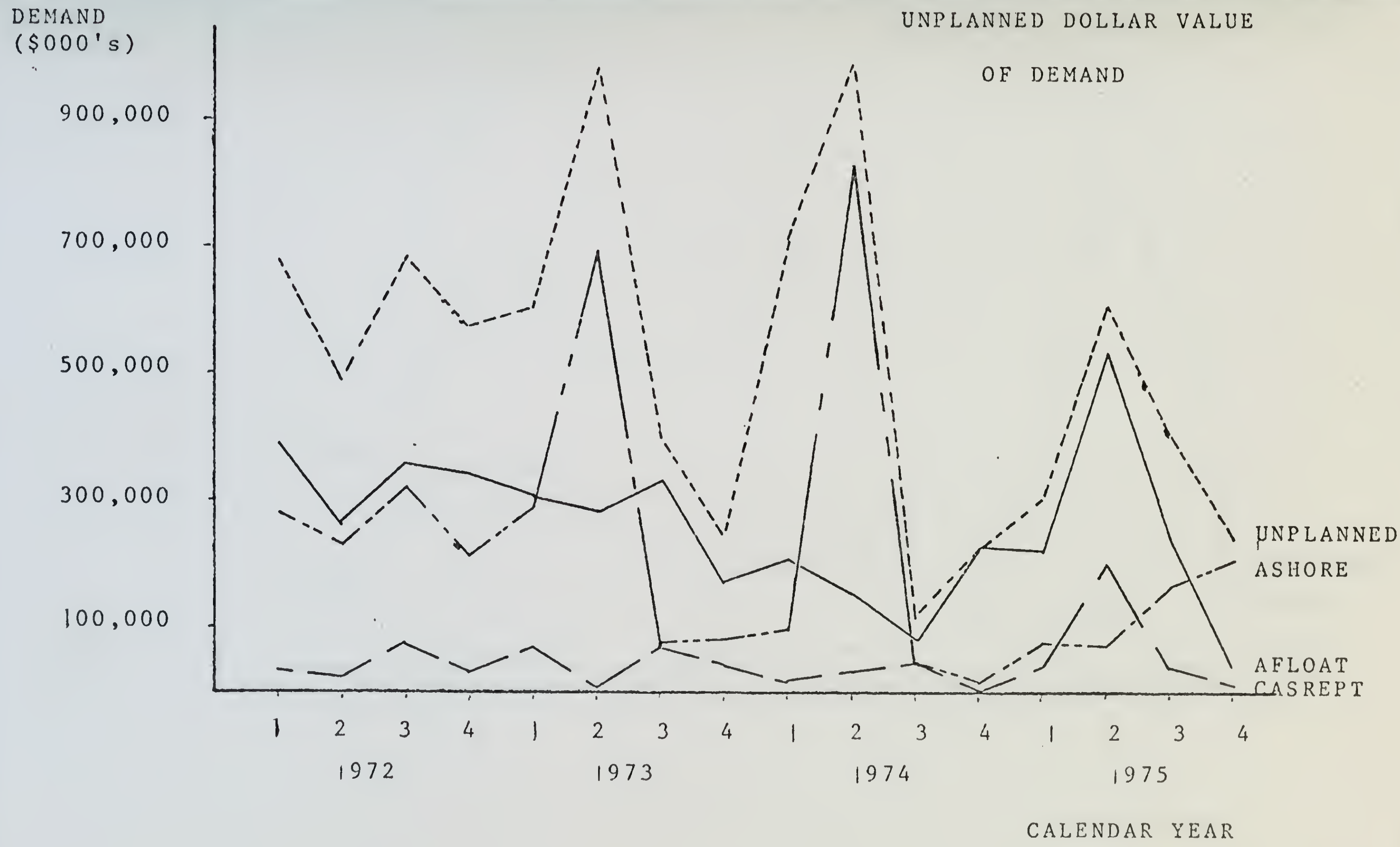


FIGURE III-14

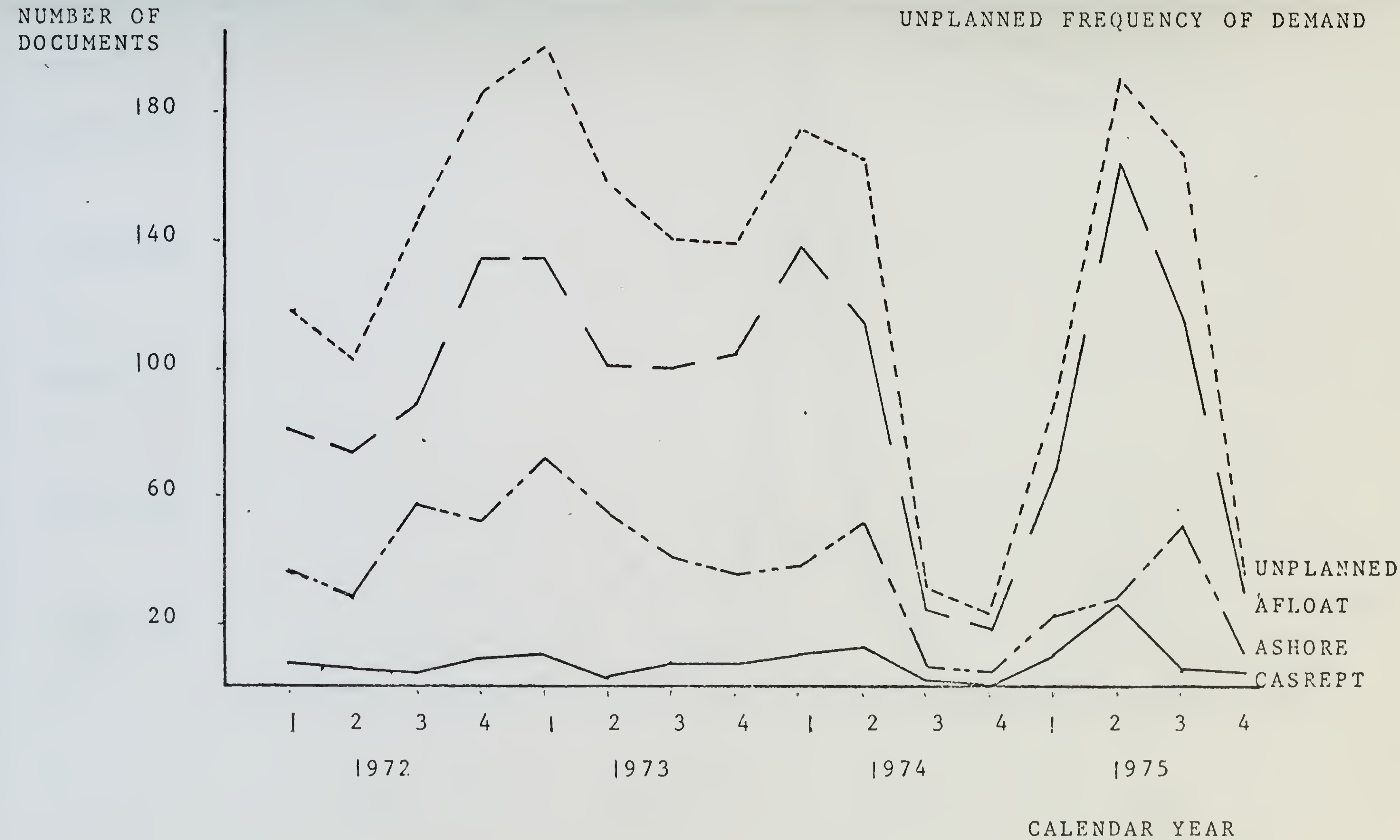


FIGURE III-15

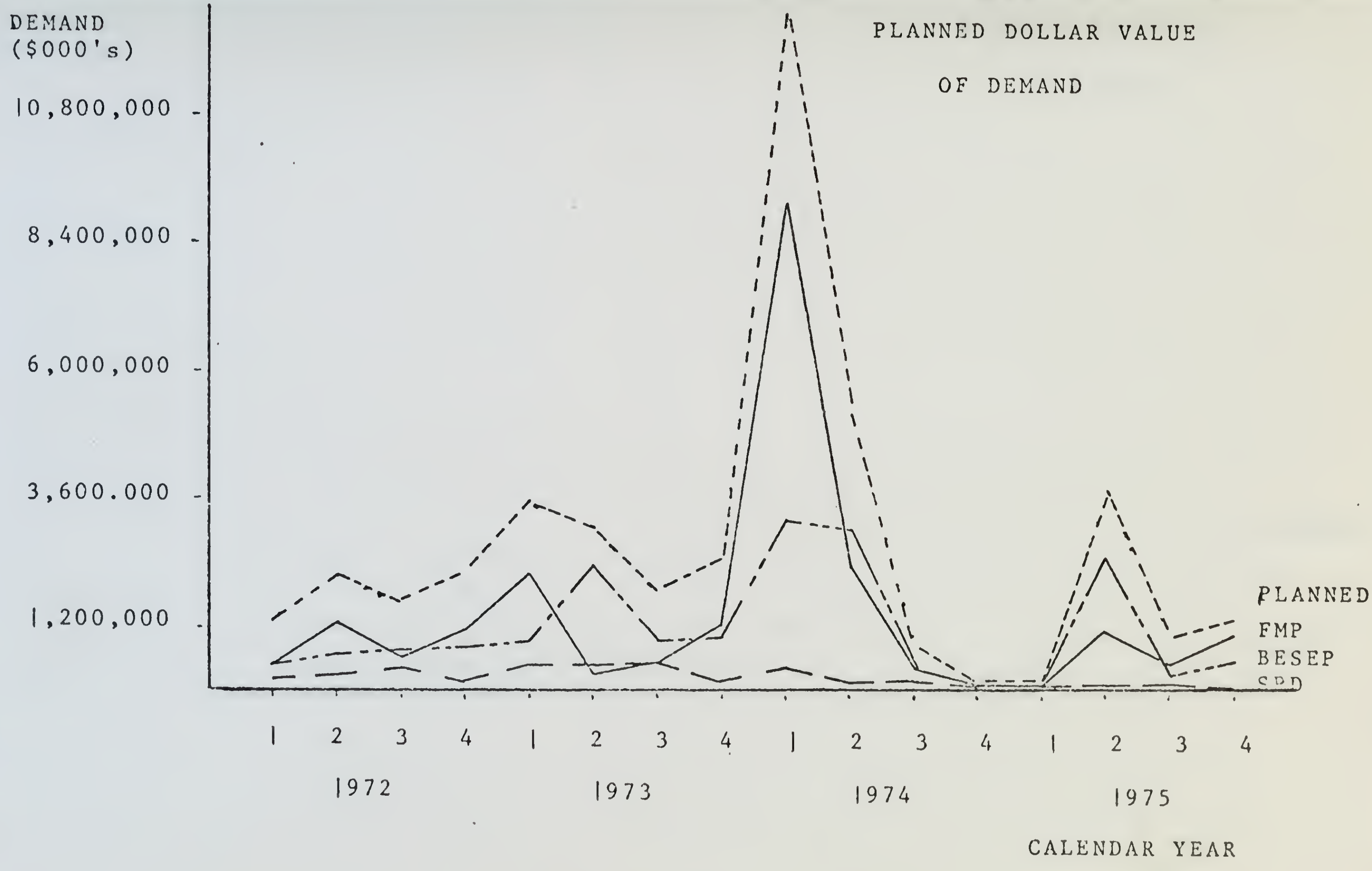


FIGURE III-16

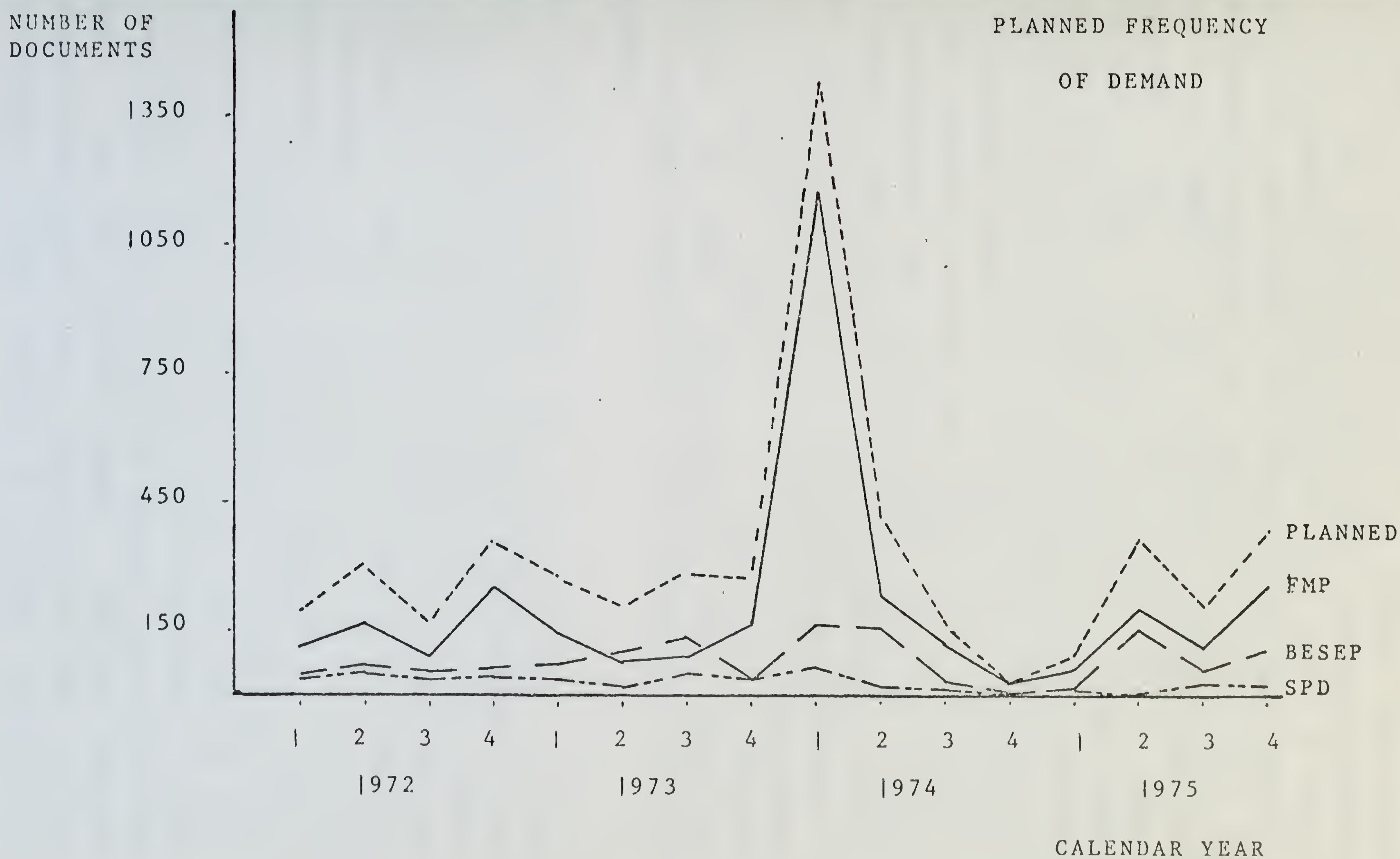


FIGURE III-17

procedure may be relatively accurate. Although there is some similarity between the pattern of demands experienced by planned and unplanned requirements, the two categories differ significantly, particularly in the case of demand frequency (i.e. the number of documents processed regardless of the quantity required per document). Note that the movement in demand for unplanned requirements is significantly more stable than that for planned requirements. This suggests that in a gross sense, unscheduled demand for NAVELEX equipments may be relatively stable and therefore somewhat predictable. Recognizing that frequency prediction would be of little value to NAVELEX, which is primarily concerned with dollar value of demand, a final conclusion on the predictability will be reserved until later in the analysis. A second important conclusion results from the magnitude of the unplanned requirements in relation to NAVELEX's overall demand. If the CENILE screen is even remotely accurate in identifying unplanned requirements, as these trends suggest, then a significant amount of NAVELEX's demand base is attributable to unplanned requirements.

In order to stratify this data further, average quarterly figures in each category were computed for the period from calendar year 1972 through 1975. The results are displayed in figure III-18. Keeping in mind that this data reflects net demand, i.e. what was ultimately demanded after adjustment for cancellations, an interesting conclusion may be drawn. Refering to appendix B, NAVELEX's funding is distributed approximately 10% O&MN, 50% afloat OPN (i.e. FMP), 10% other OPN (i.e. BESEP) and 30% SCN (i.e. SPD). Comparing these figures to those displayed in figure III-18 indicates a marked disparity between the dollar value of demand for SCN funding (6.5%) and the relative proportion of the budget (30%). These figures may reflect the fact that a major source of assets for unplanned

requirements results from the cancellation of SPDs after material has been procured. This would result in unreserved assets which could be utilized at the discretion of NAVELEX.

Average Quarterly Demand

	Frequency of demand	Percent	Dollar Value of demand	Percent
Afloat Unplanned	93	20.2	264,284	7.9
Ashore Unplanned	37	8.0	256,139	7.7
FMS	3	.6	40,922	1.2
FMP	210	45.6	1,416,304	42.5
SPD	33	7.2	217,834	6.5
BESEP	85	18.4	1,135,356	34.1
	461		$3,330,839	

Figure III-18

Note also that one category of demand, specifically Military Interdepartmental Purchase Requests (MIPR) is not included in figure III-18. Since these demands are not processed through SPCC they do not appear on the CENILE tape. Furthermore, the only records readily available on MIPR demand are accumulated by customer and not by equipment. As a result, it was not possible to incorporate MIPR data into the data base although they do represent a significant portion of NAVELEX's annual demand. Indicative of their degree of importance is the fact that annual MIPR obligations approximate $25 million as compared to $150 million in the case of OPN. Thus this source of unplanned requirements can not be ignored as a contributory factor to NAVELEX's demand base.

Keeping in mind, one of the original objectives of this analysis, that of determining if unplanned requirements represent a significant portion of NAVELEX's demand base, a significant conclusion can be drawn from figure III-18. Assuming the results of the CENILE screen represent a reasonable approximation of NAVELEX's true demand base, somewhere in the vacinity of 15% of the dollar demand received by NAVELEX is unplanned. Adding to this the fact that according to UICP files 18.8% of the equipments managed by NAVELEX experience some unplanned demand, unplanned requirements do in fact appear to constitute a significant portion of NAVELEX's demand base.

Attention is now directed toward the ability to forecast this demand. Even if the demand exists, funding support cannot be acquired unless a reliable forecasting technique is found. Initially, attention was directed toward the ability of the UICP model to forecast principal end item unscheduled demand. Analysis centered on measurement of the validity of the UICP forecast and on its ability to forecast the type of demand experienced by principal end items.

In measuring the validity of UICP forecasting, attention was initially directed toward the 81.2% of the inventory which contained zero demand forecasts. Since such items comprise such a major portion of NAVELEX's inventory and would justify no funding from a forecasted demand stand point, it was critical that demand projections be accurate in this area. Utilizing the sample NSNs obtained for processing the CENILE tape, the probability of receiving an actual demand of x units given a forecast of zero was computed. The results, as amplified in Appendix D, indicate that 91.7% of those items with a forecasted demand of zero experienced no demand in the UICP demand horizon of the last eight quarters. Thus the UICP forecast procedure appears to

perform relatively well in determining zero demand equipments. Most of those items identified as zero demand items on the MDF have, in fact, experienced no demand. The fact that 8.3% had experienced demand was of some concern, particularly in view of the fact that 44% of that segment had experienced demands greater than five in the last two years.

The UICP forecasting system is designed to accomodate relatively large quantities of demand with relatively small variations from the mean demand from each observation. In effect, as will be discussed later, UICP establishes an acceptable demand region about the mean of the historical demand observations. If a particular observation falls outside this region it is not considered in the forecast computation. For zero demand items, the band is very small, and any variability in demand which routinely falls outside the band will therefore not be considered. To avoid continuously ignoring a new demand pattern which falls outside the acceptable demand region, UICP will, if two successive quarterly demand observations fall on the same side of the band, compute a new average utilizing only those two observations and ignoring all previous data. This suggests that the 8.3% of the sample receiving demand but maintaining a zero demand forecast must be experiencing intermittant demands which are falling outside the UICP acceptable region and thus not being considered in demand forecasting. It also suggests that the UICP model inadequately forecasts demand patterns of the type experienced by many principal end items.

In analyzing UICP's ability to forecast non-zero demand items, several areas were examined. First, in an attempt to understand better the demand patterns of principal end items, a test was conducted to determine the likelihood of receiving a follow-on demand given that an initial demand

was experienced. This measure was of considerable significance since the common concept of a principal end item demand pattern is that given a demand has been experienced it is highly unlikely a second demand will occur immediately thereafter. To test this hypothesis the CENILE sample data were again utilized. The period from January 1972 through December 1975 was examined by determining the probability of getting demand in quarter Q+x given that a demand was experienced in quarter Q. The results indicated the probability of receiving a follow-on demand in the quarter immediately following an initial demand lies between .60 and .71. This suggests a significant amount of NAVELEX's demand based inventory does experience repetitive demands in successive quarters and thus could be ameanable to a forecasting procedure like that of UICP. However, care must be taken in interpreting these results. As indicated in Appendix D, the cut-off period utilized in computing the quarters between demands impacts on the computation. But this fact primarily impacts on the period between demands and not the fact that between 60% and 71% of the inventory will experience a demand in the immediately succeeding quarter if an initial demand occurs. Therefore, from a standpoint of recurring demand, a significant portion of NAVELEX's inventory appears to be compatible with the UICP forecasting technique. Although this answers a portion of the question of UICP compatibility, it does not address the magnitude of changes in demand from one quarter to the next. Even if recurring demands are being experienced for a significant portion of the inventory, UICP may still inadequately forecast the demand if the magnitudes of the demands are highly variable.

To test this hypothesis a simulation of the UICP forecasting technique was developed to determine the variability of demand from the demand forecast. Again utilizing the CENILE sample, a simple average was taken on

the first four complete quarters following the date the item entered the inventory (the first four quarters of 1972 if the item entered prior to that date). Utilizing this average as the first forecast, exponential smoothing was applied to develop forecasts for the remaining quarters through 1975. Specifically, utilizing a smoothing weight of .1, the following formula was employed:

$$F(Q+1) = .9F(Q) + .1D$$

where $F(Q)$ = the current quarter's forecasted demand

D = the current quarter's demand observation

and $F(Q+1)$ = the new forecasted demand

Having computed sample forecasts, the analysis determined the percent absolute variation, V, between the forecasted demand and the experienced demand in each quarter:

$$V = \frac{|F(Q) - D|}{F(Q)} \times 100$$

In the compilation of the data, items with a forecast of zero or a current demand observation of zero were not considered. The former would have given an indeterminate expression and the latter would have biased the results with observations of 100%. The net effect of these two exclusions is to make the results conservative in their reflection of the true variation. As shown in Appendix D, the results of this simulation showed that 13.7% of the observations were within 20% of the forecasted quantity and 30.3% were within 50%, while the mean variation was 370%. Because the magnitude of the mean variation was so large, the UICP forecast procedure is suspect.

A second test of variability is to determine the percentage of observations which fall outside the UICP filter range. To clarify the purpose and use of UICP's

filtering technique, consider a secondary end item demand base. The purpose of the filter is to minimize the impact of non-recurring demand incorrectly coded as recurring and to eliminate high or low demand observations in the computation. Thus the function of the filter is to screen abnormal demand observations from forecasting consideration. This function is accomplished by establishing a maximum and minimum value about the mean of historical demand observations. Within this acceptable range demand observations are automatically included in UICP forecasts. When an observation falls outside the filter range, a card is forwarded to the appropriate manager for review. If the manager so indicates, the observation is validated and will be considered in the demand forecast computation. Historically this seldom occurs. Therefore, demands falling outside the filter range are generally excluded from the forecast computation. As a result, if a large portion of NAVELEX's demand observations can be shown to be falling outside of the filter range, the adequacy of UICP demand forecasts would be highly questionable.

In order to test this hypothesis a simulation was conducted on the CENILE data sample using the UICP procedure for setting filter limits. A mean absolute deviation (MAD) from a simple average of demand observations was computed for the period 1972 through 1975. Filter limits were then set at the demand average ± 3.75 times the MAD as utilized by UICP. Finally, each demand observation was then examined to determine if it fell outside the filter limits. The results indicated 71.6% of the demand observations fell outside the filter range and were therefore ignored in the computation of demand forecasts. Thus it appears that UICP, in its current format, is incapable of reliably predicting principal end item demand.

Given this result, the necessity of finding an alternative forecasting technique becomes of primary importance. An attempt was made to determine if a simple modification of the UICP forecasting horizon from one quarter to one year would improve annual forecasts. In testing this hypothesis the simulation technique cited earlier was employed. By extending the forecast period to one year, the percent of the observations with a 100% or greater variation from the forecast decreased from 37.3% to 29.2%. Thus, there is some evidence that a change of forecasting horizon from one quarter to one year would result in better forecasts for the annual demand of principal end item equipments of NAVELEX. However, in order to justify this change, a more extensive data base would be required than is available at this time.

C. Asset Analysis

Given the significance of unplanned requirements to NAVELEX's demand base, the one obvious unanswered question relates to the degree to which NAVELEX will be able to respond to these requirements in the near future. The answer to this question is critical to NAVELEX since it was the motivating factor behind the initiation of this study. NAVELEX's contention is that the alternate sources relied upon in the past to fill unplanned requirements are disappearing and as a result, so is their ability to satisfy unscheduled demands. The key concern obviously centers about Navy requirements since it is these for which no direct funding is received.

The demand analysis revealed that some evidence exists to support the fact that assets resulting from cancelled new construction requirements may be filling a portion of unplanned Navy requirements. Such assets should be reflected as unreserved and would appear as assets in excess of

requirements on NAVELEX's inventory records. This suggests there may be assets already available in the NAVELEX inventory which can be utilized to satisfy unplanned requirements.

In order to test this hypothesis, an analysis was conducted on the net asset balance held for each item in the NAVELEX inventory. The net asset balance was computed from CSSR data through the use of the following formula:

$$NAB = OH + DI - DO - BO - PPR + SR(UA)$$

where NAB = net asset balance
OH = on-hand serviceable assets
DI = assets due-in in serviceable condition
DO = assets due-out
BO = backorders
PPR = planned requirements
SR = survival rate
UA = on-hand unserviceable assets

The MDF survival rate, which was earlier shown to contain system constants of .85, was utilized in this computation. However, it was not felt the inclusion of this figure would significantly alter the result. This assumption was verified through the use of a sensitivity analysis of the impact of changes in the survival rate. It was found that by increasing the survival rate of those items with systems constants to .90 no appreciable change occurred in the results (see Appendix D).

In order to place the net asset balance in a context which was more easily interpretable, the number of quarters worth of unscheduled demand which could be satisfied with this balance was computed. The UICP generated demand forecast was utilized as the basis for this computation. In so doing a conservative estimate of the number of quarters

over which the net asset balance can be applied should be obtained. This results from the fact that, as discussed earlier, UICP filters out the major variations in demand which constitute the majority of NAVELEX's demand base. Therefore, the UICP forecast only reflects those observations clustered about the mean demand and thus could be expected to understate the true experienced demand.

Given this model, computations were made on each of the 2038 equipments managed by NAVELEX. In the aggregate, as shown in Appendix D, it was found that, within five quarters, 47% of these equipments would have insufficient inventory levels to satisfy the UICP forecasted unscheduled requirements if current assets are used on a first-come-first-serve basis. This result is significant since it suggests within one year (the first of the five quarters began on 1 January 1976), NAVELEX may experience serious shortages of on-hand assets to fill unplanned requirements. Given this situation, NAVELEX will be forced to rely heavily upon alternative sources such as base closures, stricken ships, cannibalizations, and loans from assets on hand to fill future requirements. The availability of such assets in the future is questionable.

One of the original intentions of this analysis, as stated in Chapter II, was to investigate NAVELEX's dependence on the various alternative sources mentioned above. Unfortunately, sufficient historical information was not available to fully accomplish this goal. In the case of assets acquired from stricken ships and base closures, it was found the records which existed recorded only those equipments which were requested when a ship or station retirement was announced. No information was available regarding which equipments of those requested were received or of those received, which were utilized to fill unplanned requirements.

Regarding the use of assets reserved for future programs, it was determined that project managers were seldom relied upon for assets. However, it was felt that borrowing from future assets held by ELEX 504 was common. Unfortunately, the dependability of this source could not be determined since no records were available. Any conclusions on the use of cannibalizations to satisfy unplanned requirements were similarly constrained. Although this area was felt not to provide a major source of assets, no information was available to confirm or refute this claim.

As a result, it was not possible to quantify, to the extent desired, the magnitude of NAVELEX's projected asset shortages. Considering the major budget reductions which forced numerous ship retirements and base closures in the past, however, the dependence on these sources may have been significant. However, with the ever increasing advance of technology and the current trend toward a bigger fleet, there is serious doubt whether sources such as cannibalizations and stricken ships will be either available or applicable. If this is the case, it would suggest a heavier dependence on downstream borrowing and thus intensify the possibility of jeopordizing program completions due to a shortage of assets.

CONCLUSIONS

The existence of unplanned requirements as a significant factor in NAVELEX's demand base has been established. The treatment of these planned requirements in NAVELEX's inventory management system is critically dependent upon the availability of funds. Currently, unplanned requirements originating from non-Navy sources are accompanied by funding authority. Additionally, such requirements are normally not of an urgent nature and therefore do not critically depend upon the existence of immediately available assets. As a result, NAVELEX's system of support for these items has been, and undoubtedly will continue to be, based upon a policy of buy on demand.

Unfortunately, such a policy cannot be applied to Navy originated unplanned requirements for two principal reasons:

(1) No allowance is made for the funding of Navy generated unplanned requirements.

(2) Navy requirements are often of an urgent nature and require immediate availability of assets.

This analysis has concentrated on the first of these two areas, the question of funding demand based unplanned requirements originating from Navy sources. The second area relates to the question of a stocking policy once funds are supplied. The implication is that Navy generated unplanned requirements can not be processed exclusively in the same manner as non-Navy generated requirements. Since urgency is often a key concern, material must be available when demand is received for such requirements and a policy of buy on demand is unacceptable. In the case of demand based inventories, the forecasting technique to substantiate budget submissions will provide the tool to determine such

levels. However, this does not address the need for some protection in the event of demand against an item for which no such demand was forecasted. This problem becomes one of determining whether to stock one or none, more commonly referred to as stock/no-stock.

Substantiation of funding levels to support these areas of requirements revolve around:

(1) in the case of the stock/no-stock question, the ability to substantiate equipment criticality which would justify the cost associated with maintaining an inventory, and

(2) in the case of demand base inventories, the ability to forecast adequately demand based requirements and compute the funds required to support such demands.

Currently NAVELEX is more concerned with the second of these two areas since it is from here that the majority of their unplanned requirements originate. This analysis has shown that, given the current forecasting procedure, no reliable forecasts could be obtained. However, it has also shown that there is sufficient evidence to suggest originating a more appropriate procedure is possible.

The type of forecasting technique to be utilized in projecting unscheduled demand against principal end items is of major significance. The characteristics of principal end item demand patterns have shown that the UICP forecasting technique, in its present form, is not capable of handling NAVELEX's forecasting requirements. There is evidence to suggest, however, that a modified UICP technique may be applicable. Since two of the problem areas contributing to UICP's poor performance on principal end item forecasting were found to be filter settings and demand horizons, it

appears these two areas may provide a topic for further research.

Once a method of forecasting demand has been determined, a requirement for stratifying these demands against assets over some budget period is essential. Any stratification program acceptable for budgeting purposes must rely on the availability of line item characteristics as herein defined. NAVELEX's current files are heavily influenced by system constants which are not representative of historical experience and therefore cannot be expected to project reliable funding estimates.

Given reliable forecasting techniques the one remaining question relates to the need for funding. Although substantiating evidence to the degree desired was not available, some evidence does exist to support this requirement. Currently, the only source of funds which can be applied to Navy unplanned requirements at the direction of NAVELEX is O&MN repair funds. In order to maximize the application of such funds to unplanned requirements two types of uneconomical decisions often result:

(1) Repair funds are utilized for unplanned requirement protection while planned requirements are procured, thereby paying premium prices for planned requirements when savings may be obtained by repairing available carcasses.

(2) A lack of funds force a repair decision to fill an unplanned requirement when procurement may provide a faster or less expensive method of acquisition.

Of the non-funded sources utilized by NAVELEX to satisfy Navy unplanned requirements, none appear to have future potential for solving NAVELEX's asset shortage

problem. In fact, logic suggests these sources will become less useful with the passage of time.

RECOMMENDATIONS

Given the need for forecasting and stratification techniques and the immediacy of the requirement for support of unfunded unplanned requirements, the following recommendations are made:

(1) Purify the MDF of system constants and update all stratification related data elements utilizing the various listings separately provided ELEX 504.

(2) Reinstate the previous policy of coding demand documents entered into the RACC/ATS system, and hence the CENILE record, to allow demand forecasting procedures to differentiate between the various categories of demand received by NAVELEX.

(3) Initiate records to determine the actual dependence on striken ship and base closure assets.

(4) Commission a study to determine the most accurate demand forecasting technique given the characteristics of principal end item demand patterns.

It is further recommended that, to the maximum extent possible, the relationship established between NAVELEX and the Naval Postgraduate School be continued . In this respect, the following areas have been identified in the process of this study which may provide topics for additional research which would be mutually beneficial to both commands:

(1) Development of a line item stratification process for principal end item equipments.

(2) Development of a demand forecasting technique for principal end item unplanned requirements.

(3) Investigation of possible distinct flow points at which principal end items should transfer from project office to functional code to ICP.

APPENDIX A

NAVELEX Organization & Management

The purpose of Appendix A is to introduce the NAVELEX organization and how the Production Division (ELEX 504) interfaces with the various levels of management not only within NAVELEX, but also with other commands. Additionally, some essential inventory management principles are introduced and explained in the context of NAVELEX's role as an Inventory Manager (IM).

I. CNO-CNM-Systems Commands Relationships

The Chief of Naval Operations (CNO) has assigned the responsibility for all Navy material support to the Chief of Naval Material (CNM) who commands all activities of the Naval Material Command (NMC). CNM has in turn, delegated these responsibilities to the various Systems Commands, each of which specializes in material support for one major category of equipments. Figure A-1 shows the CNO-CNM relationships as well as the relationships between the various Systems Commands, e.g. the Naval Electronics Systems Command (NAVELEX); other commands under the CNO, e.g. Naval Communications Command; other Department of Defense (DOD) commands, e.g. Defense Communication Agency (DCA); and other goverment agencies, e.g. Federal Aviation Agency (FAA), State Department, and others.

A Systems Command is responsible for the development, planning, programming, acquisition, installation, logistics, and technical support and guidance for a particular class of weapons systems and their related equipments required in support of all the facets of naval operations throughout the system/equipment life cycle. For example, the Naval Sea

NAVELEX INTERFACE DIAGRAM

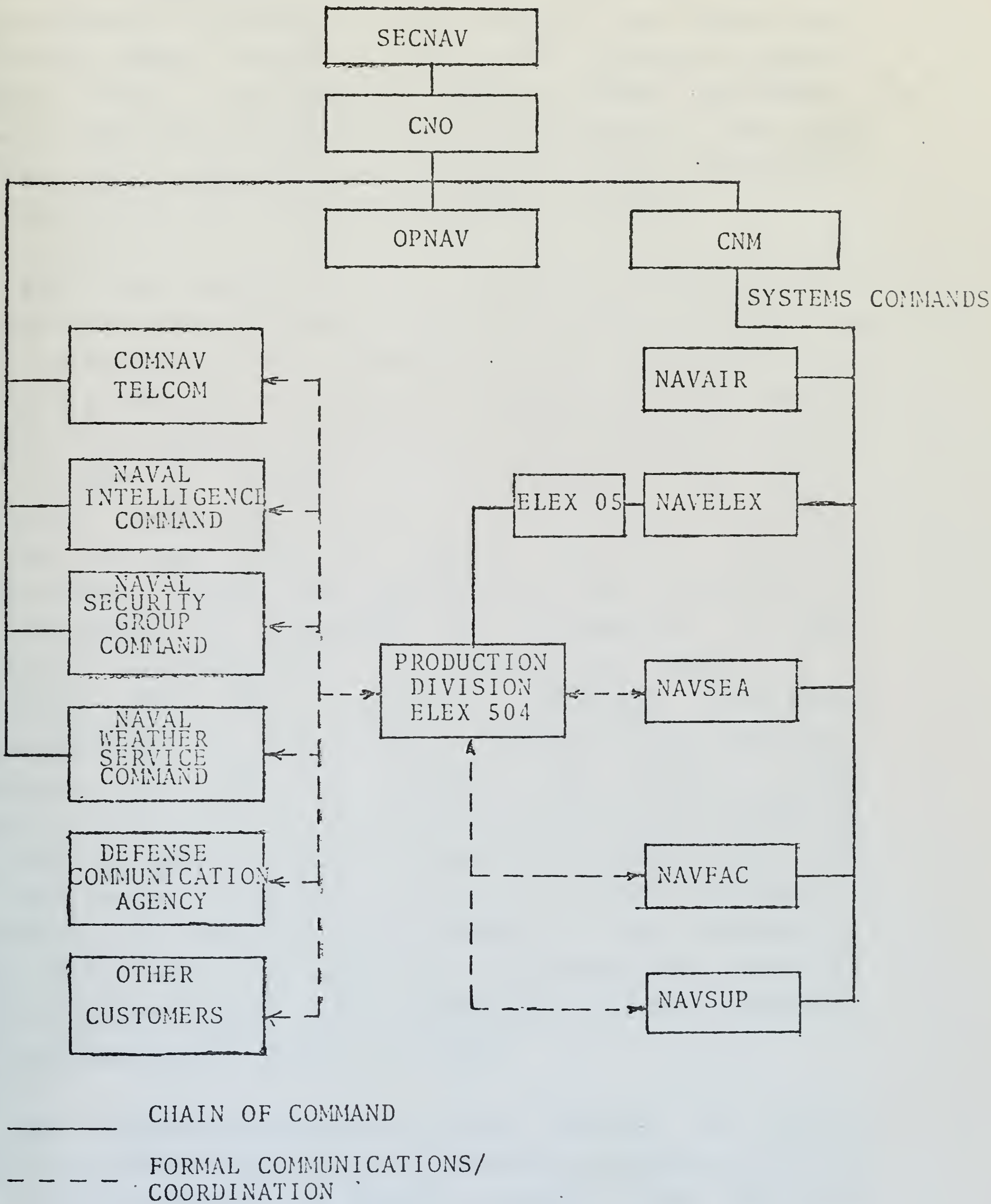


FIGURE A-1

Systems Command (NAVSEA) is responsible for that segment of the Navy pertaining to the general category of ships. This is not to imply all ship related equipments are the responsibility of NAVSEA. On the contrary, some ships carry equipments which relate to all three Hardware Systems Commands (HSC), specifically NAVELEX, NAVSEA, and NAVAIR. However, the prime equipments generally thought of as ship systems (e.g. propulsion, ship ordnance, hull, electrical, and mechanical) are the responsibility of NAVSEA.

Note the distinction made between equipments and the aggregate of these equipments, the ship itself. The ship is here referred to as a platform in the sense that it is strictly a delivery mechanism when considered in its purest context. The equipments which enable the platform to perform its mission are referred to as principal end items. Generally, an end item is selected by the CNO as a principal end item on the basis of military combat or training essentiality, taking into consideration also the difficulty of procurement or production and criticality of basic materials or components. To clarify the concept of a principal end item, several commonly considered chararteristics of such major systems can be discussed. Although, as will be pointed out later, these characteristics do not necessarily apply to every prinicpal end item, in general, they do adequately describe such items to the degree required at this point in the discussion. Typically such characteristics include a high complexity, high cost, and a long lead time to procure; the capability to be repaired through module replacement and an essentally zero probability of failure in total.

The inventory management of Navy material is divided basically between two groups of inventory managers. The type and degree of material management required will determine the group to which an item will be assigned for inventory

management purposes. When the dominant requirement is for technical/management control, inventory management is generally performed by one of the Systems Commands provided the item satisfies one or more of the following conditions:

(1) it is in a research and development stage,

(2) it requires engineering control decisions,

(3) it is unstable in design, or

(4) it is specifically assigned to a Systems Command by CNM.

Within the Systems Command, two levels of inventory management exist, project management and functional management. Project management, primarily development in nature, is generally encountered in the equipment's life cycle and is oriented toward the macro scale (i.e. management is generally thought of in terms of a ship, a gun system, an aircraft, or a communication system). With the equipment's introduction to the fleet and subsequent design stablization, the item no longer requires the intensified management typical of a project office and thus migrates to the functional organization of the Systems Command. With this transfer, the equipment begins to take on the more typical characteristics of an item of inventory, although its degree of stabilization still dictates that the Systems Command retain "hands on" control. Management orientation now shifts from the macro to a more sub-system orientation, i.e. instead of referring to a ship or aircraft the principal end item identities begin to become of primary importance as reference now centers on propulsion, avionics, and ordnance and more specifically the launcher, gun director, radar, sonar, etc. When the equipment no longer requires the Systems Command's constant technical supervision, i.e. complete design stabilization theoretically occurs, the second group of inventory managers

begins to play the leading role. At this time the dominant requirement shifts from technical support to inventory control and the item is assigned to one of the Navy's two Inventory Control Points (ICP) under the command of the Naval Supply Systems Command (NAVSUP).

One further class of material, secondary end items, should be mentioned to clarify the relationships between the various inventory management functions performed in the Navy. Secondary end items are the commonly thought of "bits and pieces," i.e. the Navy's repair parts inventories. These items are the parts which make up principal end items and are generally considered the only group for which inventory management is required. In reality this is far from the case, since, as will be discussed later, considerable unscheduled demand is being received on principal end items.

Figure A-2 displays the relationships between the three categories of materials discribed above, specifically platforms, principal end items, and secondary end items. The pictured boundaries between the various categories are not meaningless since each segment is generally thought to be under the purview of a distinct entity; platforms to project offices, principal end items to HSC functional codes and secondary end items to ICPs. This is unfortunate since considerable overlap exists in the management of principal end items and such precon3eptions tend to dictate the relationships between the three entities. Consequently, considerable difference of opinion exists over the points at which principal end items should migrate from project office to functional code and from functional code to ICP. Furthermore, ICP procedures are designed to accomodate items with the characteristics of secondary end items, not principal end items, thus some debate exists over whether ICPs should manage principal end items at all.

Material Category Relationships

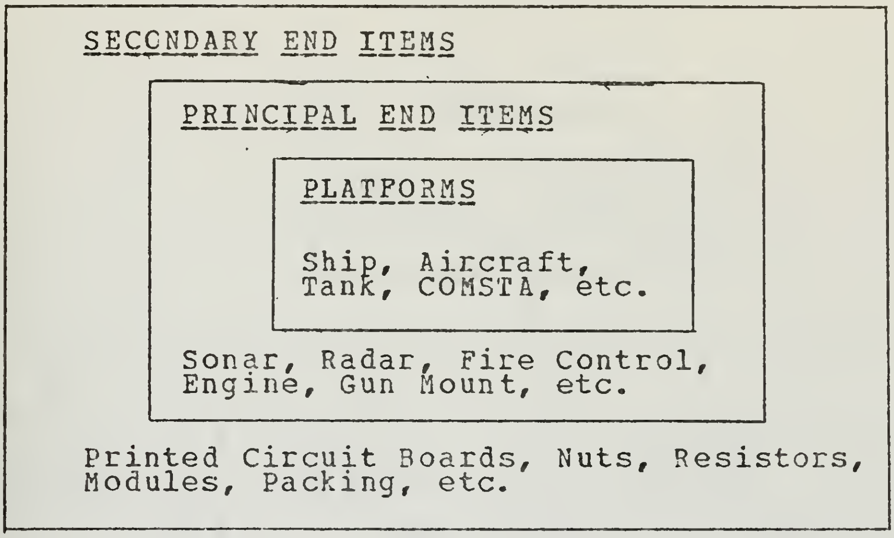


Figure A-2

Maintaining this curtailed, but essential, inventory management philosophy of the Navy in mind, NAVELEX then, is responsible for the technical/management control of the following types of principal end items:

(1) surveillance and intelligence gathering systems,

(2) communications systems,

(3) data processing and display systems,

(4) electronic warfare systems,

(5) navigation and air-traffic-control systems.

All such NAVELEX equipments are designated as 2Z cognizance material in accordance with the DOD standardized coding system which identifies specific categories of inventory.

II. NAVELEX (less ELEX 05)

Figure A-3 reflects the organizational block diagram of NAVELEX. The following paragraphs describe the basic responsibilities of each of the major directorates.

NAVELEX ORGANIZATION

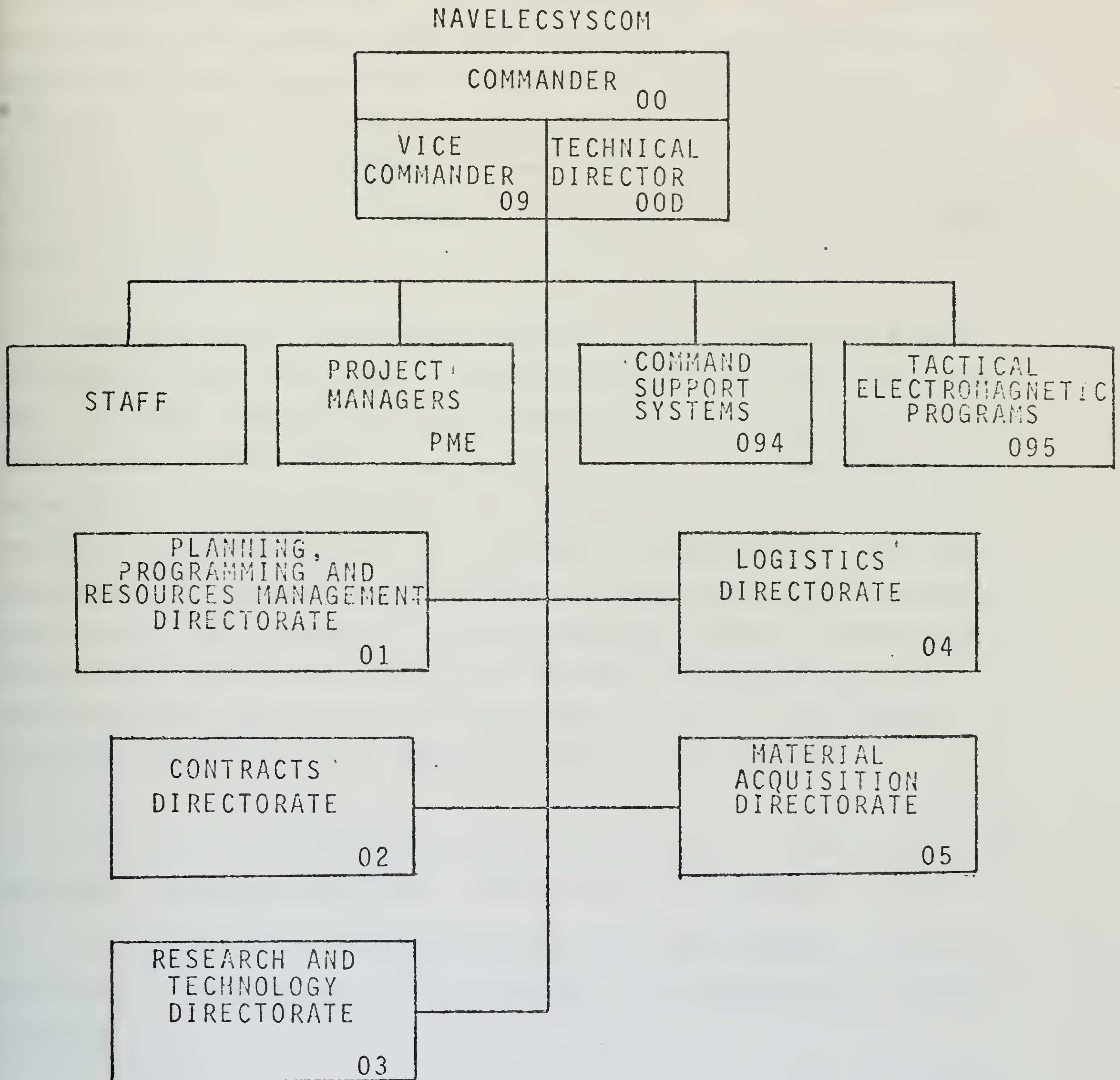


FIGURE A-3

The Planning, Programming and Resources Management Directorate (ELEX 01) is responsible for financial operations, including budget programs, preparations and estimates, and allocation of manpower ceilings within the Command. Also, the International Logistics Program Office, the Management Information Center, the Planning Division and the Field Activity Program Planning Division are located within ELEX 01.

The Contracts Directorate (ELEX 02) as the name implies is responsible for the accomplishment of the Command's contractural obligations in conformance with the applicable provisions of law and regulation. ELEX 02 develops and promulgates Command policies for award and administration of contracts, participates in advance procurement planning, prescribes the procurement method to be employed, and awards contracts for NAVELEX. Additionally, this directorate administers selected aspects of NAVELEX contracts as well as monitors and supervises the administration of contracts by Contract Administration Services field activities.

The Research and Technology Directorate (ELEX 03) is assigned responsibility for three major functional areas:

(1) The administration of the total command Research, Development, Technology, and Evaluation (RDT&E) program,

(2) Planning and execution of the command's programs for research, exploratory and advanced development as well as necessary laboratory support, and

(3) Identification, definition and acquisition of specific scientific and technical intelligence data in support of naval weapons systems research, development, engineering and testing.

The Logistics Directorate (ELEX 04) is assigned responsibility for planning and providing system effectiveness engineering, maintenance engineering management and logistics support to those systems and equipments being acquired to satisfy operational requirements from RDT&E through acquisition and operation. This directorate also provides Radio Active Test Equipment (RADIAC) management for the Command. Furthermore, it provides Integrated Logistics Support (ILS) for all system and equipment acquisitions, including later engineering change or retrofit programs. It also maintains liaison with one of the two ICPs for supply support of Command responsible equipments and develops and promulgates logistics support concepts and policies. Thus ELEX 04 acts, in part, as a type of inventory control planning directorate in that they provide direction to both functional managers and ICPs for material under the cognizance of NAVELEX. ELEX 04 also coordinates the Wholesale Interservice Supply Support Agreements (WISSA) and other intra and inter-service support agreements. These agreements pertain to the logistical support for certain families of electronic equipments of which more than one service, e.g. Army and Navy or Air Force and Navy, are registered users.

III. Material Acquisition Directorate (less ELEX 504)

Figure A-4 portrays the organizational block diagram for NAVELEX's Material Acquisition Directorate (ELEX 05) which is by far the largest directorate within the Command. ELEX 05, which is recognized to be a vital link to the successful fulfillment of NAVELEX's mission, is responsible for the acquisition management for assigned systems and equipments within its defined areas of responsibility. This includes planning, direction, and control of execution of approved development programs. Also, ELEX 05 provides business and technical management as well as planning and

MATERIAL ACQUISITION DIRECTORATE ORGANIZATION

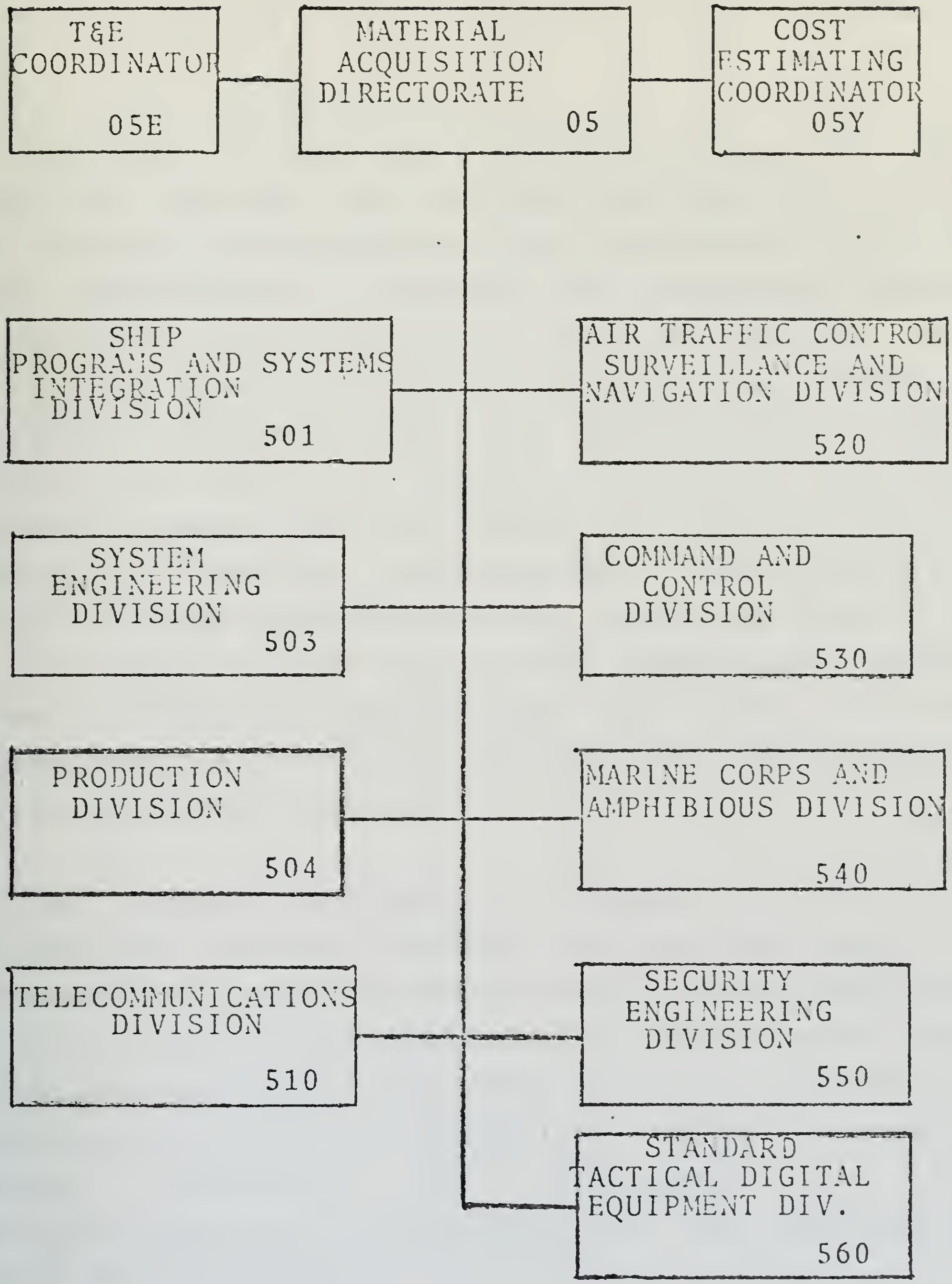


FIGURE A-4

customer liaison necessary to acquire systems and equipments. The following paragraphs describe the basic responsibilities of each of the major divisions within ELEX 05.

The Ship Programs and Systems Integration Division (ELEX 501) directs and controls the execution of NAVELEX ship oriented programs for both new construction and active fleet modernization programs for shipboard electronic systems. This division acts as a point of control for all NAVELEX ship system program commitments to the various naval activities concerned with ship acquisitions. ELEX 501 directs all aspects of system integration of shipboard electronic systems from the "cradle to grave", i.e. ship inspection, design, construction, moderization, and alteration until deactivation from the active fleet . Also, the division reviews all fleet operational electronic systems performance requirements in order to define shipboard systems and thus, initiates the appropriate action to synthesize these systems.

The Systems Engineering Division (ELEX 503), as the name implies, develops systems engineering design plans consistent with approved systems architectural requirements. It also performs system engineering reviews for the Command Support Systems Office (ELEX 094) and initiates installation design plans in order to develop and recommend appropriate actions. Finally, if necessary, it obtains contractor/laboratory assistance for the development of NAVELEX system studies.

The Telecommunications Division (ELEX 510) is responsible for the design and discipline of the various telecommunications systems. This includes planning and program management functions which entail the following: scheduling, finance, systems/equipment design, acquisition,

installation, test and evaluation.

The Air Traffic Control, Surveillance and Navigation Division (ELEX 520), the Command and Control Division (ELEX 530), as well as the Marine Corps and Amphibious Division (ELEX 540) are all self explanatory in the sense that each is responsible for that specific named functional discipline. Additionally, ELEX 530 provides technical support to the CNO for Automated Data Processing (ADP) security matters.

The Security Engineering Division (ELEX 550) is responsible for the discipline of the various cryptographic and cryptologic systems. The division assists the Commander Naval Security Group (COMNAVSECGRU) in the satisfaction of the Naval Intelligence Command special communications requirements. Also, ELEX 550 provides the engineering liaison with the National Security Agency (NSA) during the development and/or production of Communications Security (COMSEC) equipment for the Navy.

The last major division within ELEX 05, other than ELEX 504, is the Standard Tactical Digital Equipment Division (ELEX 560). This division provides the effective total equipment/system "life cycle" acquisition management and technical support to the Department of the Navy for the assigned tactical digital hardware and software systems for which NAVELEX has life cycle responsibilities.

IV. Production Division (ELEX 504)

Figure A-5 represents the organizational block diagram for NAVELEX's Production Division (ELEX 504) with which this report is primarily concerned. ELEX 504 performs the complete spectrum of inventory management functions for the major electronic equipments assigned to NAVELEX for material

PRODUCTION DIVISION ORGANIZATION

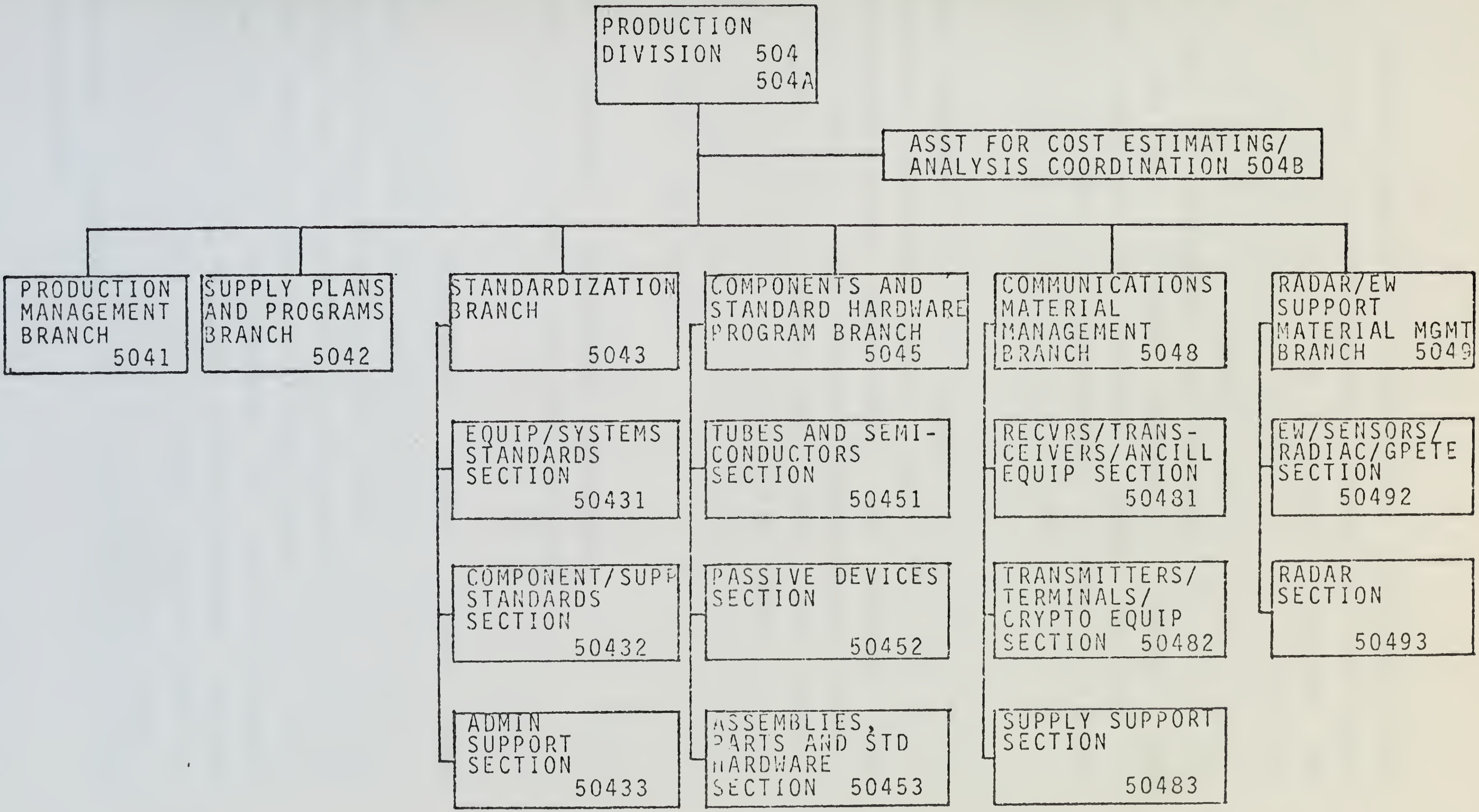


FIGURE A-5

support, and thus performs the functional management role mentioned earlier in the discussion of principal end items. The division is responsible for developing policies and procedures for processing procurements of production hardware, preparation of procurement documents when assigned and providing of management information on procurement programs. ELEX 504 provides engineering support for electronic components and materials which includes the review of non-standard parts submissions and the management of the Navy Standard Hardware Program (SHP).

These responsibilities are carried out by six branches: the Production Management Branch (ELEX 5041), the Supply Plans and Programs Branch (ELEX 5042), the Standardization Branch (ELEX 5043), the Components Engineering & Standard Electronic Model Program Branch (ELEX 5045), the Material Management (Communications) Branch (ELEX 5048), and the Material Management (Radar Early Warning (EW) Support Equipment) Branch (ELEX 5049).

The following paragraphs describe the basic responsibilities of each of the above branches.

The Production Management Branch (ELEX 5041) establishes policies and procedures for the management of ELEX 504 production operations. This branch plans material acquisitions for both short-term and long-term projections. One of the essential functions of this branch is to control the operation and maintenance of the Requirements Accumulator/Acquisition Tracking System (RACC/ATS). RACC/ATS was designed to provide an automated system which will satisfy the information needs of all levels of management in the successful execution of the acquisition responsibility placed upon NAVELEX.

The Supply Plans and Programs Branch (ELEX 5042) reviews and analyzes all supply management directives, policies and procedures issued by higher authorities. The branch participates in the analysis, as well as develops concepts, methods and procedures to implement changes to the Uniform Inventory Control Point (UICP) programs as these changes affect the management of 2Z cognizance material. Also, ELEX 5042 analyzes and implements the necessary programs and procedures to link RACC/ATS and UICP. Finally, this branch acts as the point of contact within NAVELEX for the Equipment Dictionary (EDICT) Automated Data System as well as the Command's administrator for the Uniform Material Movement and Issue Priority System (UMMIPS).

The Components and Standard Hardware Program Branch (ELEX 5045) provides engineering support to ensure the availability of appropriate standards, specifications and other criteria for component reliability, maintainability, quality control and value engineering. ELEX 5045 reviews and recommends approval or disapproval of non-standard parts and components in Navy electronic equipments. Also, this division manages the Navy's SHP.

The Communications Material Management Branch (ELEX 5048) manages all matters pertaining to the inventory control of assigned 2Z cognizant assets which include receipt, identification, issue, restoration, stratification, stock coordination, item management review, condition coding, reservation, disposal, financial inventory accounting and reporting. The division provides direct support to afloat and ashore activities on all matters concerning standard DOD requests, reports and documentation. ELEX 5048 also conducts periodic requirement determination reviews to ascertain maintenance replacement levels, projected restoration requirements, adequacy of procurement plans and disposal actions. This branch deals with the

inventory management of receivers, tranceivers

and ancillary equipments plus transmitters, terminals and crypto equipments.

The Radar-EW-Support Material Management Branch (ELEX 5049) has the same overall responsibilities as ELEX 5048 for the inventory control of assigned 2Z cognizant assets. These assets are electronic sensors, radiac equipments and General Purpose Electronic Test Equipment(GPETE) as well as the radar and EW equipments.

V. ELEX 05-ELEX 504 Program Management Interfaces

In order to assure optimum support to all customer requirements for shore-based electronic systems, certain airborne and shipboard electronic equipments, and multiplatform electronic systems, NAVELEX has found it essential to establish direct lines of communication between not only the branch, division and directorate levels within the Command, but between other Systems Commands, other Naval Commands, the DCA and other goverment agencies. NAVELEX accomplishes this objective by utilizing program managers in a matrix organization, allowing this necessary direct line of communication.

Because NAVELEX is responsible for providing engineering and material support for electronic systems and equipments, a program manager will be designated whenever the complexities of a program warrant special and centralized management attention. As is recognized, program management is nothing more than a management technique to devote a concerted effort to the planning, direction, control and evaluation phases of a specific program. It assures optimum and timely implementation by all NAVELEX codes and others so as to effectively support the recognized

and approved program.

ELEX 05-ELEX 504, as one of the functional codes in the project manager's matrix organization, has a management responsibility to identify individual program planning participants and to assist in carrying out the various planning actions necessary for a successful program. Thus, ELEX 05-ELEX 504 must interface with every major directorate within NAVELEX as well as other commands in order to pursue required actions in the following key functional fields:

(1) programming and budgeting,

(2) system design and development,

(3) logistics planning,

(4) acquisition management, and

(5) procurement and contracting.

APPENDIX B

NAVELEX's Inventory System

Figure B-1 displays the key elements of an inventory system. Referring back to Appendix A, note that the equipments managed by NAVELEX, being complex in nature, are invariably material which can be restored to a serviceable condition through repair. Thus, one of the key sources of material in a principal end item inventory system is repair of unserviceable equipments. The purpose of this section is to introduce NAVELEX's functional role as an Inventory Manager IM. Therefore, as displayed in figure B-1, the key elements to be considered include demand; sources, including acquisition through both repair and procurement and on hand stocks; funding and the internal management information system utilized by NAVELEX to coordinate these elements.

I. Demands

The demands placed on NAVELEX fall into two major categories, planned and unplanned. Planned requirements are generally connected with a specific program and as such are submitted to NAVELEX in advance of the required delivery date. As a result, adequate time normally exists for NAVELEX to respond to these requirements through procurement or repair without jeopordizing the timely completion of the program to which they relate.

Unplanned requirements, on the other hand, are often received by NAVELEX with an immediate delivery requirement, thus minimizing the alteratives open to supply the needed material. For example, the most critical class of unplanned requirements would include material required to correct a ship's casualty as reflected on a casualty report (CASREPT)

BASIC INVENTORY MODEL

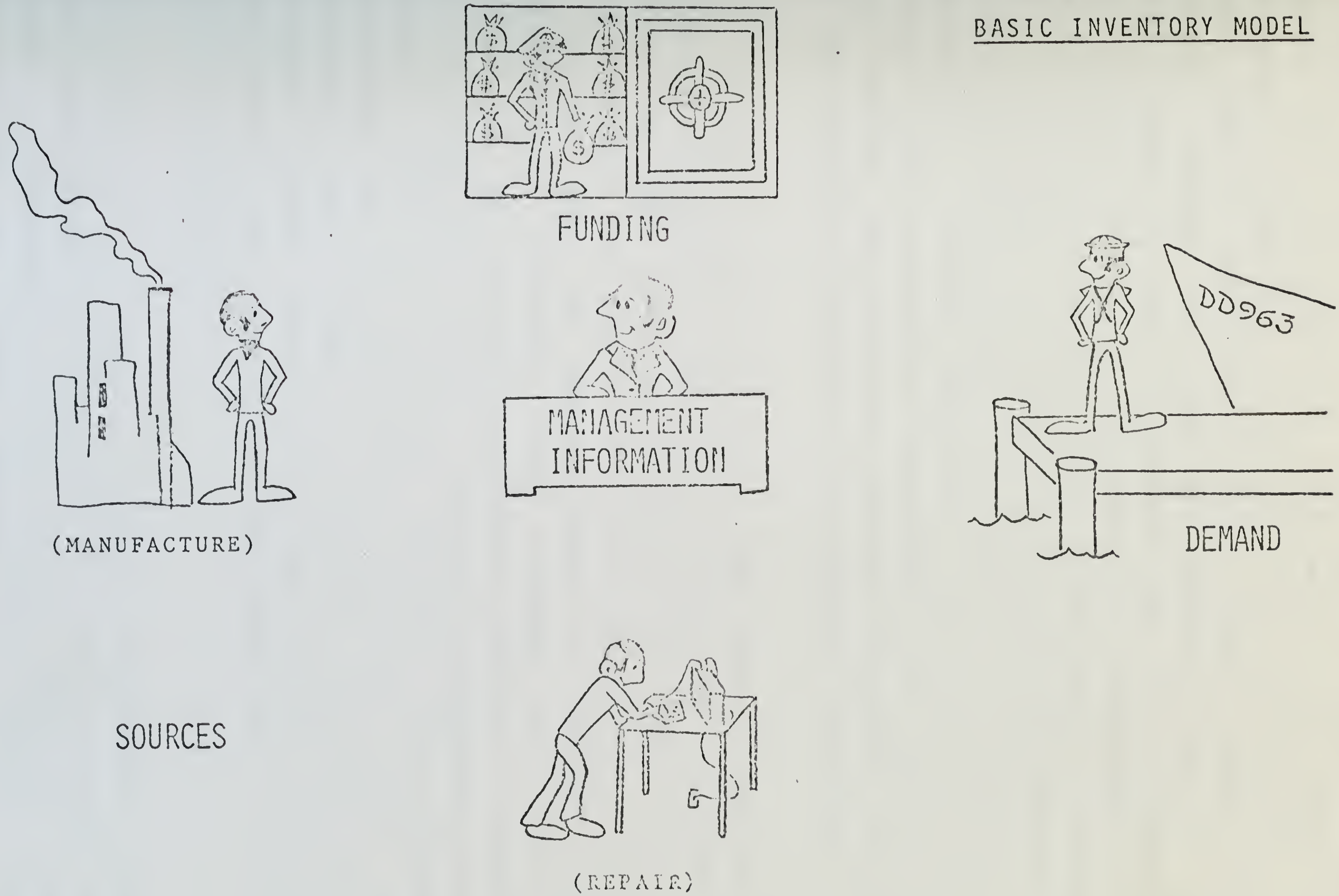


FIGURE B-1

and the least critical a shore based requirement with little immediacy attached to it. The key to differentiating between planned and unplanned requirements is the receipt of "planning" information in advance of the material need. A common point of confusion in this respect arises when relying strictly on allowable response time as the distinguishing characteristic between the two categories. For example, because a requirement is submitted with a required delivery date (RDD) beyond an acquisition timeframe (i.e. the period in which routine acquisition procedures would allow NAVELEX to obtain the material) it is frequently considered a planned requirement. This is not the case, however, since, although the requirement lacks urgency, it was received with no advance planning information and thus is more correctly classified as an unplanned requirement.

Although, from a response time aspect, NAVELEX is primarily interested in the class of unplanned requirements which have RDDs within an acquisition time frame, they are also concerned with many of those with little urgency due to a critical need for funding support to satisfy these requirements. Currently, funds accompany only a small portion of the unplanned requirements received by NAVELEX. Thus two additional classes of unplanned requirements can be defined; funded and unfunded. Therefore, each unplanned requirement can be described in two ways: urgent or non-urgent and funded or unfunded. Obviously then, NAVELEX's concern centers on urgent unfunded unplanned requirements which constitute their most critical problem area of requirements.

Within the category of planned requirements, three sub-categories exist: Basic Electronic Shore Equipment Plan (BESEP) requirements, Ships Program Directive (SPD) requirements, and Fleet Modernization Program (FMP)

requirements. In each case, planning documents are the key to NAVELEX's receipt of actual hardware requirements.

BESEPs, unlike the other two sub-categories of planning documents which provide NAVELEX with planned requirements, orginate within the overall NAVELEX organization. In general, they represent all planned requirements applicable to shore based activities. The need for such a document orginates outside of NAVELEX, primarily through the Naval Telecommunications Command (COMNAVTELECOM), and is normally in response to either the creation of a new shore installation or the update of currently installed shore equipments. As a result of the determination of such a need, NAVELEX, in conjunction with the user activity, orginates the planning document, the BESEP. Thus, when the BESEP is complete, it acts as the source document for all requirements, both hardware and otherwise, which NAVELEX will be required to furnish to fulfill the need established by the user command.

Notice that, for shore based planned requirements the BESEP functions as the planning document for both new construction and modernization. In the case of afloat planned requirements these functions are separated into two areas: the SPD representing new construction and the FMP representing modernization. In the case of the SPD, although NAVELEX participates heavily in the planning leading to this document much the same as it does with BESEPs, the Ship Program Directive is prepared by NAVSEA and submitted to NAVELEX as the detailed description of requirements needed for a specific ship acquisition program. In the case of ship modernization, once again NAVSEA provides the ultimate statement of requirements, but in a somewhat different form. The FMP represents the culmination of planning by NAVSEA, NAVELEX, and Type Commanders (i.e. the administrative

commanders of the particular class of ships in question) for future fleet modernization. The specific requirements identified in the process are then supplied to NAVELEX through a system known as the Ship Alteration Management Information System (SAMIS). Thus, SAMIS functions as the source document for FMP requirements much as the BESEP and the SPD in their respective areas.

Having introduced the three sub-categories of planned requirements, three sub-categories also exist within the classification of unplanned requirements: Military Interdepartmental Purchase Request (MIPR) requirements, Foreign Military Sales (FMS) requirements and Navy requirements.

MIPRs represent the requirements of other services and federal agencies for NAVELEX managed equipments. They are received in the form of a requisition direct from the activity concerned and processed on an individual basis. All MIPRs are accompanied by funds and as such can be classified as funded unplanned requirements.

A second class of requirements which are always funded are FMS requirements which, although classified as unplanned requirements, in a sense fall somewhere between planned and unplanned. When a foreign government identifies a need for NAVELEX material, a request is submitted through OPNAV to NAVMAT by the country's embassy in Washington,D.C. This request, in a sense, acts as a planning document. However it does not authorize NAVELEX to make an acquisition. The document serves as a request for proposal in which the country interrogates NAVELEX's sources of assets to determine if material can be provided. NAVELEX, in return, through OPNAV, provides an offer to the country in question

which the country is under no obligation to accept. If the offer is accepted the Navy International Logistics Control Office (NAVILCO) in Bayonne, New Jersey, becomes the Navy's coordinator and submits appropriate funded requisition documents to NAVELEX. It is not until these documents are received that NAVELEX is authorized to take action on FMS requirements, hence their designation as unplanned requirements.

The final sub-category of unplanned requirements, and the sole source of unfunded unplanned requirements, is Navy requirements. Such requirements are received from any Navy activity and normally represent a need which has arisen with little, if any, advance notice. Invariably, these requirements are of greatest concern to NAVELEX since they represent their own service's needs. Unfortunately, as will be discussed later, they are also the most difficult to satisfy.

<u>Demand Category Summary</u>

PLANNED REQUIREMENTS	SHORE BASED	BESEP
	AFLOAT BASED	FMP SPD
PLANNED REQUIREMENTS	NAVY	SHORE BASED AFLOAT BASED
	NON-NAVY	MIPR FMS

Figure B-2

In summary, NAVELEX's demand base is as reflected in figure B-2. Within the two major categories of planned and unplanned requirements fall a total of seven sub-categories. Thus NAVELEX must respond to a wide variety of customers with varied and often conflicting needs.

II. Sources

Having accounted for NAVELEX's demand base, the next key element to consider is the sources from which NAVELEX obtains the material to satisfy these demands. Primarily, referring back to figure B-1, NAVELEX relies on four major sources of material:

(1) assets currently on hand in the NAVELEX inventory,

(2) assets obtained through repair of non-ready-for-issue carcasses,

(3) assets procured from civilian manufacturers, and

(4) assets returned by users in either serviceable or unserviceable condition in the form of material turned in to store (MTIS).

These, however, are not the only sources of material utilized by NAVELEX. Due primarily to either a lack of adequate funding or the urgency of a particular requirement, NAVELEX is sometimes required to seek material assets from non-normal sources such as downstream borrowing, program manager loans, stricken ship and base closure assets, and reserve fleet cannibalizations.

NAVELEX's on hand inventories fall into three categories:

(1) material acquired for planned requirements which has been prepositioned pending delivery,

(2) material originally acquired for a planned requirement but whose requirement has since been cancelled, and

(3) material acquired through repair of uncommitted carcasses in anticipation of future demand.

This latter category is highly restricted since it can only be maintained through repair of MTIS assets and not through procurement. This is because NAVELEX receives no advance procurement funding to support anticipated demands for unplanned requirements.

NAVELEX's repair program centers around the return of unserviceable, but repairable, assets from their customers. Normally, providing the repair cost is reasonable with respect to replacement price (i.e. the cost of an entirely new unit obtained through procurement is within approximately 75% of the repair cost as stated in NAVELEX Instruction 4408.2B), NAVELEX maximizes the use of its repair program. Thus, as requirements are identified and found not to be available from on hand assets, repair is the first area of alternate supply investigated.

The repair program is managed jointly by the Logistics Directorate (ELEX 04) and the Material Acquisition Directorate (ELEX 05). The execution of this program occurs at NAVELEX field activities where the source of repair is determined. Thus, for example, ELEX 504 identifies a requirement and an unserviceable carcass and requests ELEX 04 to initiate repair action. ELEX 04 then contacts the various field activities for bids on repair cost. Once all bids are received, ELEX 04 assigns a work request to the selected field activity and the field activity in turn either accomplishes in house or contracts with another activity or commercial contractor for the ultimate repair of the unserviceable carcass.

One special repair program was initiated by NAVELEX in response to a request for special handling of afloat requirements from ships undergoing restricted availiabilities (RAV) or overhauls in shipyards or alongside tenders. Since such requirements represent unfunded demands on NAVELEX assets and require rapid response, a unique equipment pool was created in conjunction with fleet TYCOMs to allow for instantaneous turnaround of these items. Thus, NAVELEX is able to maintain an inventory of repaired assets specifically for this program and TYCOMs are able to draw on this inventory for their ships as long as an unserviceable carcass and funds for its repair are supplied in return. This program, termed the Direct Equipment Exchange Program (DEEP), although at the present time limited to only 15 items, provides a valuable service to afloat units.

If material cannot be obtained through repair, the final routine source of assets is through procurement. In this case ELEX 504 interfaces with the Contracts Directorate (ELEX 02) for procurement support. However, if timing is a factor or if funds are not provided such as with unfunded unplanned requirements, alternate sources must be found. Two of these sources result from base closures and striken ships (i.e. ships that are to be striken from the naval register and either sold or scrapped). In both cases, NAVELEX has priority in obtaining any assets which are to be offloaded. NAVELEX's policy in these situations is to acquire all material for which requirements are currently on hand or for which forecasted demand indicates a future need. Although these assets are generally not in new condition, they do represent a "free" source of assets to NAVELEX which does not have to be replaced.

The remaining asset sources constitute more crisis oriented sources of material which are only temporary

solutions to an immediate need. In these cases, assets obtained must be replaced at some future date. Examples include borrowing from assets reserved for downstream program requirements and loans from project manager assets as well as cannibalizations from reserve fleet ships. Borrowing frcm downstream assets involves ELEX 504 utilizing assets reserved for planned requirements with future RDDs in anticipation of resupplying the borrowed material prior to the program RDD. Similarly loans from project managers constitute essentially the identical process with the exception that the material is obtained not from ELEX 504 inventories but through loan from assets held by individual project managers. The final crisis category, cannibalizations, involves removal of required assets from a reserve (i.e. inactive) ship, also to be replaced at some later date. However, since there is no set timeframe in which cannibalized equipments must be replaced, these assets generally cause less concern to the inventory manager.

III. Funding

As is normally the case in most inventory systems, funding is the key factor in the operation of NAVELEX's inventory system. Due to the various categories of requirements which are placed on NAVELEX, several funding sources exist which provide the necessary financial support to enable NAVELEX to function efficiently. In the case of unplanned requirements, funds generally accompany the requisition submitted to NAVELEX and are provided by the ordering activity. This is true of both FMS and MIPR requirements. However, in the case of Navy requirements, unplanned requirements generally are unfunded. The reasoning behind this lack of funding is based upon both a rational budget policy and an irrational assumption about the failure cf prinicipal end items.

The individual commands within the Navy cannot, with their relatively meager budget allocations, be expected to budget for items with prices the magnitude of principal end items. Thus such equipments are covered in a separate account, the Appropriations Purchase Account (APA), and issued free to Navy customers. Funds for such equipments arise from annual Congressional appropriations, however, such funds are designated to provide for module type assets (i.e. those secondary end items which fall between piece parts and principal end items) and not for items for which a need is never anticipated such as principal end items. Thus, NAVELEX, which is responsible for the inventory management of 2Z cognizance principal end items for which demand does originate from within the Navy, has a source of demand for which no funding is provided. Therefore, their ability to respond to these requirements centers on the availability of unused assets from the other sources mentioned previously.

In the planned requirement universe this lack of adequate funding does not pose a problem. In the case of SPDs, funding authorization is included in the documentation received by NAVELEX from NAVSEA. The budget process itself is therefore the responsibily of NAVSEA and requires funding authorization before the SPD is issued. NAVELEX, however, is not involved in this process and simply awaits receipt of the completed SPD to initiate acquisition action with the use of the Shipbuilding and Conversion, Navy (SCN) funds supplied by NAVSEA.

The process through which FMP and BESEP requirements are funded involves considerably more NAVELEX participation. In both cases NAVELEX provides the budget submission for those requirements for which acquisition action will be required within the budget year. Thus SAMIS and BESEP

planned requirements with RDDs which require material acquisition within the budget year will be submitted for funding through the formal budget process. Depending on the planned source of assets to fill these requirements, such budget requests would include Operation and Maintenance, Navy (O&MN) funds for installation and repair costs; and/or Other Procurement, Navy (OPN) funds for funding of civilian contractor supplied assets.

It should be recognized that the budget request submitted in any one year does not represent the first time such requirements have been presented. In fact, BESEP and FMP requirements form a portion of the Navy's Program Objective Memorandum (POM) submission and as such are forecasted by NAVELEX, as accurately as possible, up to seven years in advance as displayed in figure B-3.

FUNDING HORIZON

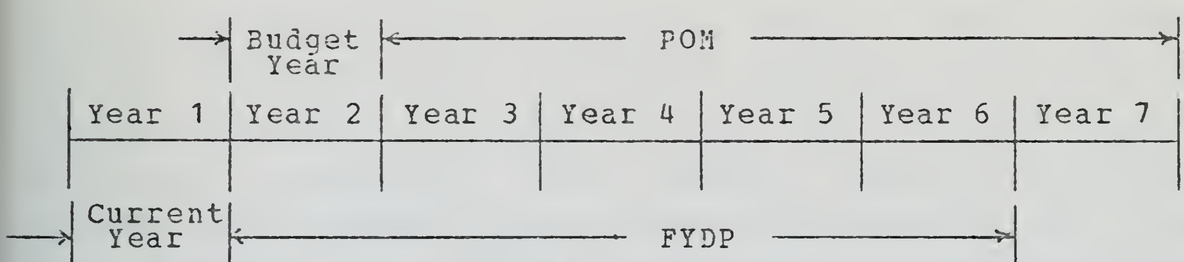


Figure B-3

Unfortunately, predictions of future requirements at such a distant horizon are highly uncertain. For example, NAVELEX estimates that FMP requirements at a five year horizon only represent approximately 25% of the requirements which will be received in any one year. And beyond that, the NAVELEX management information system, which will be discussed later, does not even project requirements. Therefore, much of the indecision associated with projections of planned requirements are not resolved prior to the final budget

submission the year before acquisition action must be taken. As a result, although BESEP and SAMIS documentation provide firm requirements to NAVELEX, no acquisition action can be initiated on these requirements until funds are authorized through the formal budget process. This is in marked contrast to the processing of both SPDs and funded unplanned requirements, both of which have funds accompanying the requirement documentation. As a point of reference, NAVELEX's annual budget expenditures are distributed approximately 10% O&MN, 50% OPN for afloat users (i.e. FMP requirements), 10% for other OPN users, and 30% SCN.

IV. Management Information System

NAVELEX's ability to control their inventory system centers around a final key element termed the Requirement Accumulator/Acquisition Tracking System (RACC/ATS). This management information system was designed to provide an automated system that will satisfy the informational needs of all levels of management as well as provide a method of automating the inventory management process within NAVELEX to the greatest extent. RACC/ATS, therefore, serves as the central mechanism for coordinating the various elements mentioned previously. For example, RACC/ATS maintains records of all NAVELEX requirements authorized in the Five Year Defense Plan (FYDP), it determines when acquisition action will have to be initiated, what source is to be utilized, and what the respective cost is estimated to be. Additionally, RACC/ATS tracks the flow of documentation through NAVELEX and provides current fund balances relating to individual requirements. With respect to procurement actions it consolidates requirements, checks stock assets, determines cognizant procuring activities, checks existing contracts for uncommitted options or multi-year quantities unexpended, generates schedules to meet RDD and fund obligation dates and monitors specific milestones to alert

management tc possible problem areas. Additionally, the RACC/ATS system provides milestone package releases as well as management reports displaying outstanding planned requirement and contract release schedules.

RACC/ATS, therefore, provides NAVELEX with the internal essential elements of a management information system. However, it does not provide the link between NAVELEX and its environment. Since supply procedures are designed to maximize the automatic processing of all requirements, some system must exist to interface NAVELEX with the supply system in total. This vital link is provided by the Navy Ships Parts Control Center (SPCC) in Mechanicsburg, Pennsylvania. SPCC receives all requirements for ship and electronic related parts which are under inventory management of the Navy. SPCC itself is the inventory manager for all seccndary end items falling in these classes as well as a select number of principal end items which have migrated to it from the HSCs. The bulk of the prinicpal end items managed in the Navy are retained by the HSCs, however, and all requirements for such items received by SPCC are forwarded to the appropriate HSC for action. In addition to this routing function SPCC provides a cataloging function for both NAVSEA and NAVELEX as well as the autcmated equipment to maintain its files. This cataloging function includes maintenance of NAVELEX inventory balances by location on the Master Data File (MDF) as well as the characteristics of NAVELEX's inventory on both the MDF and Weapons System File (WSF). The WSF typically contains the technical data pertaining to individual items, such as manufacturers part numbers, procurement sources and installed population while the MDF contains inventory management data such as forecasted demand, replacement price and procurement lead time. Thus SPCC provides the final link

which allows NAVELEX a connection to its customers and a completed inventory management system.

APPENDIX C

Cummulative End Item Ledger (CENILE) Screening Procedure

Analysis of the CENILE data received through SPCC, uncovered a wide variety of source documents which could not be considered as valid demands. Furthermore, it was immediately evident that in the majority of cases, duplicate documents existed which would have to be purged before attempting to analyze NAVELEX's historical demand.

The initial breakdown of the CENILE tape, as it was received from SPCC, was as shown in figure C-1. Several categories of documents appearing on the tape were immediately determined to be of no consequence to demand calculations. As a result, all documents citing document identifiers 105, A4R, A6, ABV, DAC, DAD, DGA, DZA, D4, D6, D8 and D9 were purged from the tape leaving 135,072 records remaining to be screened.

Examination of the remaining documents yielded no consistent pattern of screening which could be automated. Therefore, it was at this point that the decision was made to screen manually a 20% sample of NAVELEX's inventory rather than attempt manual processing of the entire CENILE tape. Upon identification of the sample stock numbers to be utilized, a sort was performed to identify those records of the 135,072 which would be screened; 27,495 such records were identified.

Figure C-2 describes the essential elements of the manual screen conducted on the 27,495 records relating to the sample. The requirement for a manual review originated

Initial CENILE Tape Contents

Document Identifier	Description	Quantity	Percent of Total
100	PPR cancellation	21,088	13.0
101	PPR with unidentified consignee	971	.6
102	PPR with identified consignee	21,385	13.0
105	Change to SUPAD of a PPR	48	.0
106	Change to quantity of a PPR	95	.0
ABV	Supplied through procurement	427	.3
AC	Requisition cancellation	6,766	4.2
A0	Requisition	6,867	4.2
A3	Passing order	4,377	2.7
A4	Referral order	21,905	13.5
A4R	NAVELEX generated referral order	20,073	12.4
A5	Referral order to a CRAB activity	1,015	.6
A6	Bounceback from a CRAB activity	24	.0
DAC	Inventory adjustment	417	.2
DAD	Inventory adjustment	13	.0
DGA	Reservation for war reserve	486	.3
DZA	Asset balance card	3,704	2.3
D4	Receipt from due	158	.1
D6	Receipt from other than due	1,284	.8
D7	Issue directive	50,602	31.2
D8	Inventory adjustment	175	.1
D9	Inventory adjustment	221	.1
	Total Records	162,101	99.8%

Figure C-1

primarily due to the quantity variations which occured on multiple documents which were otherwise identical. The net result of this screen was to eliminate 58% of the records of the CENIIE tape leaving a total of 11,670 individual documents to be considered in the demand analysis.

The final step in the processing of the CENILE data was the distribution of demands into the various categories of requirements received by NAVELEX. This was accomplished through the screen outlined in figure C-3. Several comments pertaining to this process are in order:

(1) Once a document has been coded as a FMS, CASREPT, SPD, FMP, BESEP, or unplanned requirement, it ceases to move through the screen and the next document is introduced.

(2) The UIC table referred to in item 2 was constructed from the listing of UICs found in the Navy Comptroller Manual, Volume II. The rational for checking only the first four digits of the UIC for numeric versus non-numeric values is that Navy UICs frequently have an alpha character in the final position but never in the first four. All non-numeric UICs represent NAVELEX created psuedo UICs for shore activities without a Navy assigned UIC.

(3) The CASREPT table referred to in item 3 was constructed from both project code and serial number coding policies used to identify CASREPTs within the Navy. Specifically, all documents with a G or W in the first position of the serial number; or with a project code of 706, 707, 756, 757, or XB1; or with a K in the second position of the project code and an O in the third position were coded as CASREPTs. At the completion of this screen the 11,670 CENILE records introduced were found to be 1.2% FMS, 1.6% CASREPT, 10.4% SPD, 43.9% FMP, 18.1% BESEP and 24.8% unplanned.

Document Screen

(1) Delete all records with document identifiers equal to 100 and routing identifiers equal to D7.

(2) Match 100 documents to either 101 or 102 documents by quantity and requisition number and delete matching documents.

(3) Match AC documents to either A4, A3, or AO documents by quantity and requisition number and delete matching documents.

(4) Delete all unmatched 100 and AC documents.

(5) Retain all documents with the first document identifier of the below list encountered, deleting all others with the same requisition number: 102, 101, AO, A3, A4, A5, and A7.

(6) If more than one document with dissimilar MILSTRIP formats but the same requisition number remains from (5), retain the most complete Military Standard Requisition and Issue Procedure (MILSTRIP) document.

(7) If more than one document with identical MILSTRIP formats and the same requisition number remains from (5), retain only one document.

(8) In all cases, if quantities of documents with identical requisition numbers vary, screen on an exception basis.

Figure C-2

Demand Category Screen

(1) If the service code of the document is equal to P, code the document as a FMS requirement.

(2) If the first four digits of the unit identification code (UIC) are non-numeric, code the document as a shore requirement, otherwise, screen the UIC table and code the document as shore or afloat accordingly.

(3) If the document is coded as afloat, screen the CASREPT table and code the document as CASREPT if found.

(4) If the document is coded as afloat and not a CASREPT, perform the following screen:

(a) <u>If the first position of the serial number is Z</u> (pre- RACC/ATS), and the fund code is AY or 99, code the document as a SPD, otherwise code it as a FMP.

(b) <u>If the first position of the serial number is Y or V</u>, and the second position of the project code is equal to A, B, C, D, Q or W (new allowances), code the document as a SPD, otherwise code it as a FMP.

(c) <u>If the first position of the document identifier is 1</u>, and the second position of the project code is A, B, C, D, Q or W or the advice code is 5E or 5R, code the document as a SPD, otherwise code it as a FMP.

(d) If none of (a) through (c) have been met, code it as an afloat unplanned requirement.

(5) If the document is coded as a shore requirement, and the first position of the serial number is Z, Y or V, or the first position of the document identifier is 1, or the advice code is 5E or 5R, code the document as a BESEP otherwise code it as a shore unplanned requirement.

Figure C-3

APPENDIX D

EXPLANATION OF PROBABILITY COMPUTATIONS

Appendix D discusses the probabilistic measures utilized in analyzing the predictability and variability of demand.

I. Validity of UICP Zero Demand Forecast

A sample of 396 NIINs representing all stock items with NIIN ending in 8 or 9 was extracted from the MDF. Of those items the UICP model forecasted zero demand for 266. Given this sample, a screen of the CENILE file was then conducted for demand quantities actually received. Only items which had been in the inventory for 8 quarters during the period of 1974 -1975 were considered. Of the 266 NIINs with a zero demand forecast no record existed on the CENILE tape for 194, therefore, these were assumed to have experienced no demand. For the remaining items the actual demand expressed during the eight quarters was accumulated to be used as an input to the probability computation. These results were then used to calculate the conditional probability that a demand quantity of X would be received in the succeeding eight quarters given that the forecasted quarterly demand was zero, i.e.,

$$\text{PROB(DEMAND} = X \mid \text{ZERO FORECAST)} = \frac{\text{NUMBER ITEMS WITH ZERO DEMAND FORECAST \& X DEMAND}}{\text{NUMBER ITEMS WITH ZERO DEMAND FORECAST}}$$

The results are displayed in figure D-1.

Validity of UICP Zero Demand Forecast

Demand Quantity	Number of Items	Probability
0	244	.917
1	7	.026
2	1	.004
3	3	.011
4	0	.000
5	1	.004
6-10	4	.015
11-25	4	.015
26-50	1	.004
51-100	0	.000
101-200	1	.004
201+	0	.000

Figure D-1

II. Follow-on Demand Conditional Probability

From the original sample of 396 NIINs, a sample of those items which had experienced a demand in one quarter and a demand in at least one subsequent quarter were considered. For the 16 quarter period of 1972 - 1975, 71 NIINs met this criteria. The statistics were then compiled as follows for each item: given a demand in a quarter, if a demand was received in the third quarter following that quarter, then the count for Q+3 was incremented by one. If a demand was received in the quarter immediately following this one then the count for Q+1 was incremented by one, and so forth. The conditional probability that a demand would occur in quarter Q+X given that a demand occurred in quarter Q was then calculated for each item.

$$\text{PROB(DEMAND OCCURS IN QTR Q+X} \mid \text{DEMAND IN Q)} = \frac{\text{\# QTRS IN WHICH DEMAND OCCURRED IN A PARTICULAR Q+X QTR}}{\text{TOTAL \# QTRS IN WHICH A DEMAND OCCURRED}}$$

Figures D-2 and D-3 illustrate the results of this analysis. The method of counting a demand in a particular Q+X category gave little emphasis to those items which experienced their final demand in an early quarter. For example, if an item received its last demand in quarter 9, then 7 quarters remained in which zero demand was experienced yet this factor was not considered in the probability calculation. As a result, an alternate computation in which demand was assumed to occur in the first quarter of 1976 was conducted, giving some weight to the number of quarters remaining after the final quarter in which demand occurred. Figure D-3 displays the results.

Follow-on Demand Probability

(sample size = 372)

Quarter	Q+1	Q+2	Q+3	Q+4	Q+5	Q+6	Q+7	Q+8	Q+9
Nbr Qtrs	264	43	26	21	7	4	3	3	1
Probability	.710	.116	.070	.056	.019	.011	.008	.008	.002

Figure D-2

Alternate Follow-on Demand Probability

(sample size = 472)

Quarter	Q+1	Q+2	Q+3	Q+4	Q+5	Q+6	Q+7	Q+8
Nbr Qtrs	285	66	37	29	9	5	15	6
Probability	.604	.140	.078	.061	.019	.011	.032	.013

Quarter	Q+9	Q+10	Q+11	Q+12	Q+13	Q+14	Q+15
Nbr Qtrs	3	1	4	5	2	2	3
Probability	.006	.002	.009	.011	.004	.004	.006

Figure D-3

III. Variability of Forecasted Demand

From the original sample of 396 NIINs, those items which had been in the inventory for at least five quarters (the minimum period for which a forecast can be computed) were selected for an analysis of the variability between the forecasted demand and actual demand. The demand period of 1972-1975 was considered. The variability was determined utilizing the forecasted demand as the base for measurement.

$$\text{VARIABILITY} = \frac{(\text{FORECASTED DEMAND} - \text{ACTUAL DEMAND}) \times 100.}{\text{FORECASTED DEMAND}}$$

Those items with actual demand of zero were excluded as the variability would compute to be 100% and those items with a forecasted demand of zero were excluded to preclude dividing demand by zero. Given the results of this computation, the probability that the variability of an item would fall into a specific range was computed using the following formula:

$$\text{PROB(VARIABILITY = RANGE K)} = \frac{\text{\#QTRS IN RANGE K}}{\text{TOTAL \# QUARTERS}}$$

Figure D-4 illustrates the results of this analysis. Figure D-5 illustrates the same results considering annual forecasted demands.

Quarterly Forecast Variability

Ranges of Percent Variation	800+	799-700	699-400	399-200
Nbr Qtrs	29	15	16	27
Probability	.09	.05	.05	.09
Cumulative Probability	.9	.14	.19	.28

Ranges of Percent Variation	199-100	99-50	49-20	19-0
Nbr Qtrs	30	102	52	43
Probability	.10	.32	.16	.14
Cumulative Probability	.38	.70	.86	1.00

Figure D-4

Annual Forecast Variability

Ranges of Percent Variation	800+	799-700	699-400	399-200
Nbr Qtrs	8	3	8	8
Probability	.06	.03	.06	.06
Cumulative Probability	.06	.09	.15	.21

Ranges of Percent Variation	199-100	99-50	49-20	19-0
Nbr Qtrs	10	56	23	11
Probability	.08	.44	.18	.09
Cumulative Probability	.29	.73	.91	1.00

Figure D-5

IV. Number Quarters Worth of Unscheduled Demand

In order to determine if sufficient assets were on hand to satisfy unplanned demand a net asset balance was calculated for each of the 383 NAVELEX stock items with a forecasted demand. The input data was obtained from CSSRs and used in the following formula:

$$NAB = OH \pm DI - DO - BO - PPR \pm SR(UA)$$

where NAB = net asset balance

OH = on-hand serviceable assets

DI = assets due-in in serviceable condition

DO = assets due-out

BO = backorders

PPR = planned requirements

SR = survival rate

UA = on-hand unserviceable assets

Since the survival rate has previously been shown to contain a system constant, both .85 and .90 rates were used in those records identified as having system constants. There was no significant difference in the results. Then using the only forecast available across the entire spectrum of the NAVELEX inventory, the UICP generated quarterly demand forecast, the net asset balance for each item was divided by this figure. This determined the number of quarters worth of demand on hand for each item. The results are shown in figures D-6 and D-7.

Number of Quarters on Hand

Nbr Qtrs on hand	0	1-5	6-15	16-30	31-50	50+
Nbr Items	124	56	62	51	28	62
Probability	.324	.146	.162	.133	.073	.162
Cumulative Probability	.324	.470	.632	.765	.838	1.000

Figure D-6

Number of Quarters on Hand

(SR = .90)

Nbr Qtrs on hand	0	1-5	6-15	16-30	31-50	50+
Nbr Items	123	56	63	49	28	64
Probability	.321	.146	.165	.128	.073	.167
Cumulative Probability	.321	.467	.632	.760	.833	1.000

Figure D-7

BIBLIOGRAPHY

1. Chief of Naval Material Instruction 4000.33, Material Planning Study, 11 June 1971.

2. Chief of Naval material Instruction 4440.37C, Stock Coordination Responsibilities for Navy Inventories; policy concerning, 7 February 1973.

3. Chief of Naval Operations Instruction 3721.5G, Naval Air Traffic Control, Air Navigation Aids and Landing Systems (NAALS) Program, 19 September 1975.

4. Chief of Naval Operations Instruction 4200.4A, Spare Equipments; requirements, budgeting and procurements policy for, 19 July 1972.

5. Department of Defense Instruction 4140.2, Determination of Initial Requirements for Secondary Items Spare and Repair Parts, 7 August 1974.

6. Department of the Navy, Master List of Principal Items (less Marine Corps), October 1970.

7. Department of the Navy, Navy Policy and Standards for Supply Management, 25 May 1969.

8. Graessle, Philip C., Stocking Objectives for Slow Moving Repair Parts, MS Thesis, Naval Postgraduate School, Monterey, California, 1965.

9. Inventory Manager's Manual, Introduction Levels Demand Leadtime, Mechanicsburg, Pennslyvania: CACI, Inc., April 1974.

10. Inventory Manager's Manual, Stratification, Mechanicsburg, Pennslyvania: CACI, Inc., April 1974.

11. Inventory Manager's Manual, Supply Demand Review, Mechanicsburg, Pennslyvania: CACI, Inc., April 1974.

12. Morgan II, John Henry and Scott, Norman Stuart, An Evaluation of the Problem Areas in the Implmentation of the Ship Project Directive Process, MS Thesis, Naval Postgraduate School, Monterey, California, September 1973.

13. Naval Electronic Systems Command Instruction 4000.7, Policy and Procedures Regarding Response within NAVELEX to Fleet CASREPTS (Casualty Reports), 29 July 1971.

14. Naval Electronic Systems Command Instruction 4000.9, Approval of Material for Service Use, 19 October 1972.

15. Naval Electronic Systems Command Instruction 4120.8, Standard Hardware Program, 8 March 1971.

16. Naval Electronic Systems Command Instruction 4200.8C RACC/ATS (Requirements Accumulator/ Acquisition Tracking System); procedures for use of, 11 December 1973.

17. Naval Electronic Systems Command Instruction 4408.2B, 2Z Cognizance Material Depot Level Repair Program; policy procedures, and responsibilities for, 15 June 1973.

18. Naval Electronic Systems Command Instruction 4410.2, Equipment Dictionary (EDICT) Operating Procedures, 20 December 1974.

19. Naval Electronic Systems Command Instruction 4440.1, Stock Coordination; NAVELEX Policies and Procedures for, 2 October 1969.

20. Naval Electronic Systems Command Instruction 4440.6A, 2Z Cognizance Electronic Equipment Distribution and Release; policy and procedures for, 1 February 1971.

21. Naval Electronic Systems Command Instruction 4440.6B, 2Z Cognizance System/Equipments Distribution, Requisition and Turn-in; policy and procedures for, 14 August 1973.

22. Naval Electronic Systems Command Instruction 4440.8, Material Control of NAVELEX Government Furnished Material (GFM), 29 June 1970.

23. Naval Electronic Systems Command Instruction 4720.3, Management Procedures and Responsibilities within NAVELEX for the Fleet Modernization Program (FMP), 16 June 1975.

24. Naval Electronic Systems Command Instruction 4920.1B, Foreign Military Sales Price and Availability Information; responsibility and procedures for handling, 25 February 1975.

25. Naval Electronic Systems Command Instruction 5430.1A, Organization Manual, 30 April 1974.

26. Naval Electronic Systems Command, Requirements Accumulator/Acquisition Tracking System (RACC/ATS) Operating Procedure Manual, December 1975.

27. Naval Sea Systems Command Instruction 4410.1, Supply Level Policy for Major Shipboard Equipment, 27 August 1975.

28. Naval Sea Systems Command Instruction 4720.2, Fleet Modernization Program (FMP) Standard Information Recording and Transmission Procedures; promulgation of, 7 October 1975.

29. Naval Sea Systems Command Instruction 4720.3, Fleet Modernization Program; policies, procedures, and responsibilities for, 7 November 1975.

30. Naval Sea Systems Command Instruction 7000.3, Ship Project Directive System; implementation of, 30 July 1975.

31. Quade, E. S. and Boucher, W. I., System Analysis and Policy Planning-Applications in Defense Seventh Edition, New York: American Elsevier Publishing Company, Inc., 1975.

32. Secretary of the Navy Instruction 4000.5B, Preparation of Material Planning Studies for Principal Items of Material, 8 January 1971.

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Professor F. R. Richards Code 55Rh Naval Postgraduate School Monterey, California 93940	1
Commander, Naval Electronic Systems Command Code ELEX 504 Naval Electronic Systems Command Washington, D.C. 20360	15

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